Investigating Landscape Vulnerability to Water Erosion on the Islands of Moloka'i and Kaua'i Using Remote Sensing

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• An important issue in coral reef environments is the impact of on-land pollution, including the amount of sediment delivered to the reef due to water erosion.

• A major concern is the potential impact that land use practices on an island may have on the amount of soils eroded onto the reef.

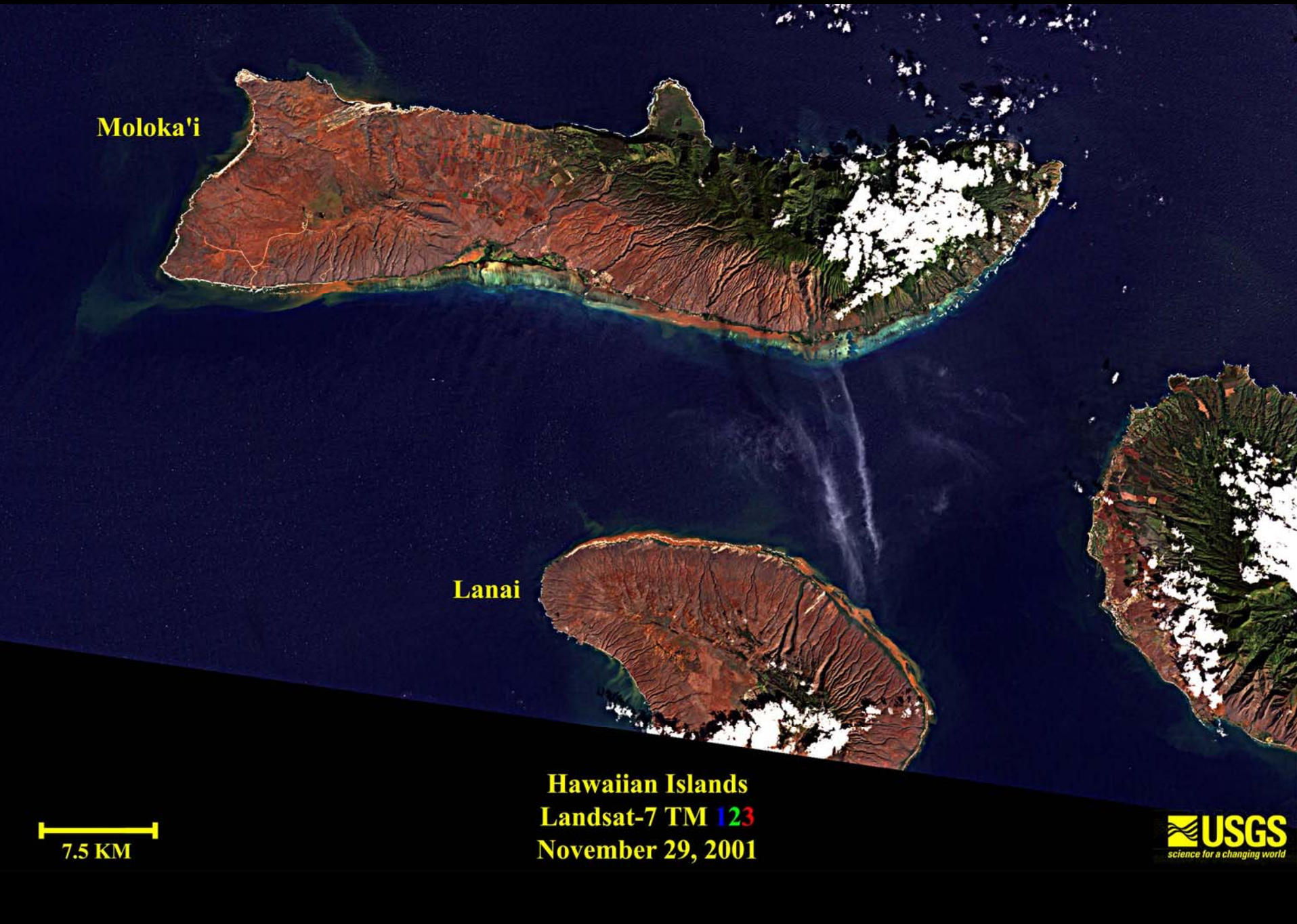
• The United States Coral Reef Task Force identified land-based pollution as one of six priority threats on which to focus efforts to protect coral reefs.

Remote Sensing of Suspended Sediment on the Moloka'i Reef

- Satellite Imaging --- Landsat TM image two days after a medium size Kona storm on Moloka'i

- Airborne Imaging --- Aerial photography collected approximately ten minutes before the Landsat TM image was collected

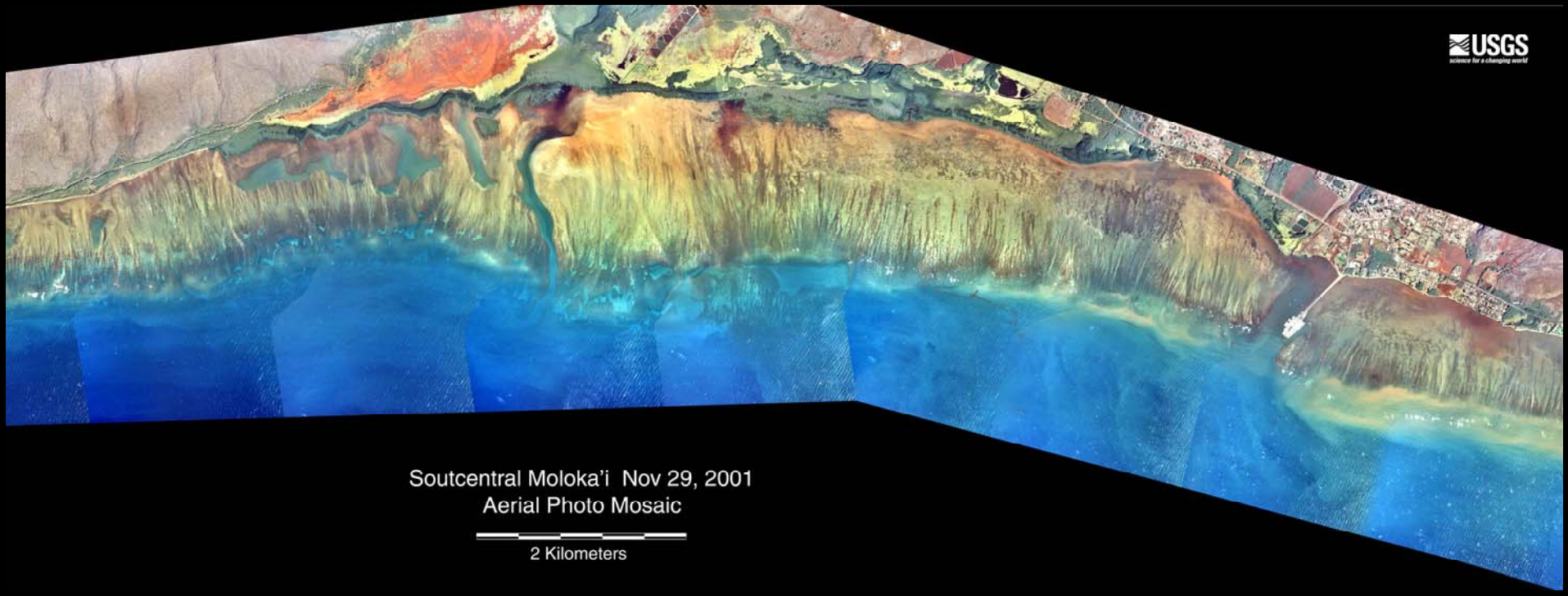
- Land-Based Imaging --- On-land automatic digital camera station to help monitor suspended sediment on the reef at Moloka'i on a daily basis


Moloka'i
Lanai
7.5 KM
Hawaiian Islands
Landsat-7 TM 123
November 29, 2001
USGS
science for a changing world

Southwest Moloka'i Nov 29, 2001
Aerial Photo Mosaic

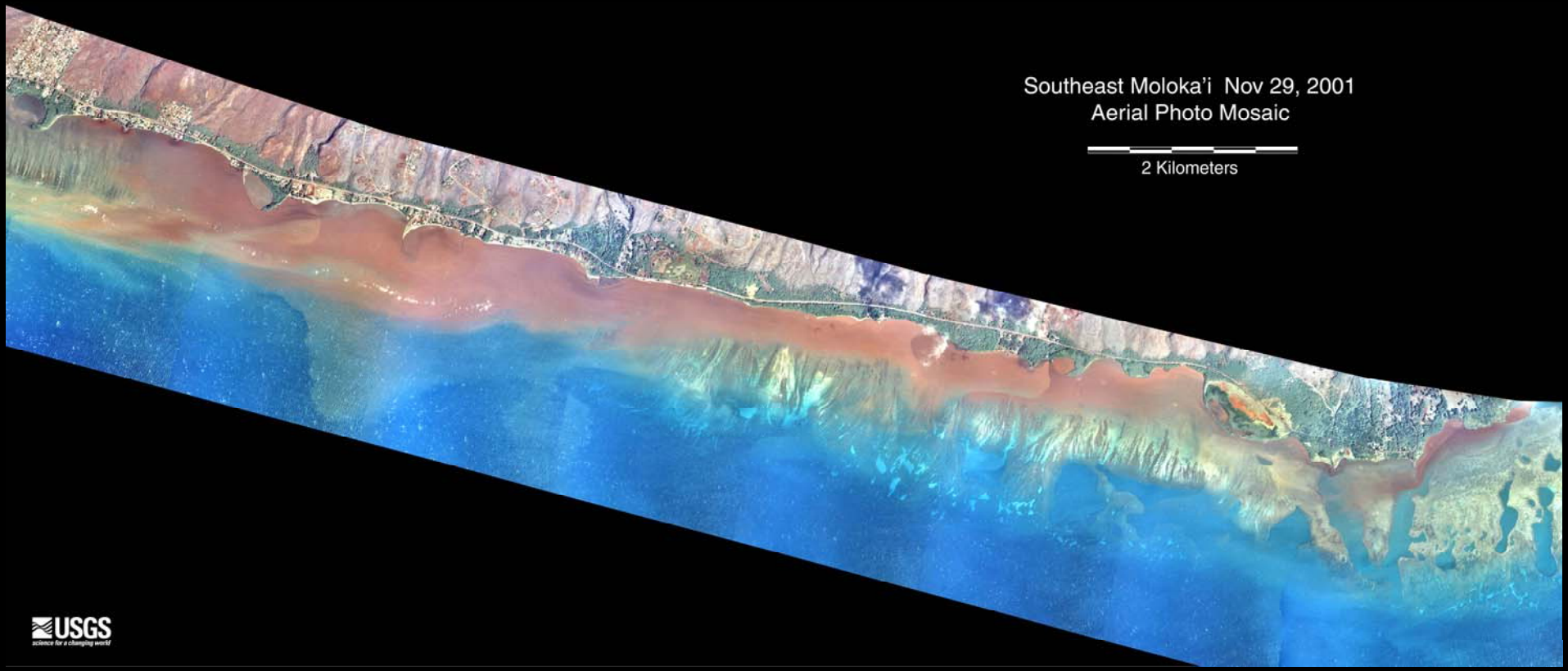
2 Kilometers

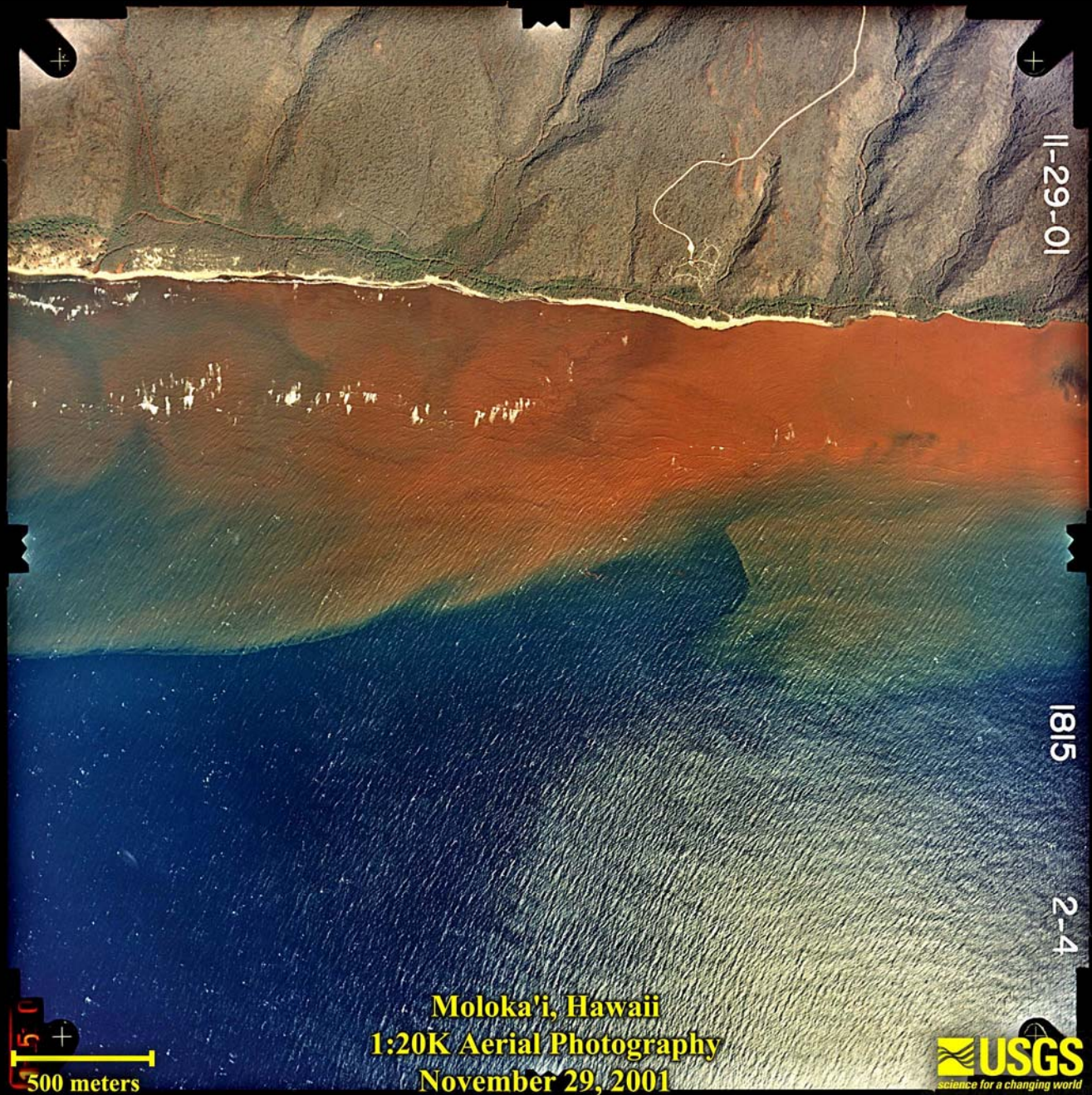
USGS
science for a changing world



Soutcentral Moloka'i Nov 29, 2001
Aerial Photo Mosaic

2 Kilometers


Southeast Moloka'i Nov 29, 2001
Aerial Photo Mosaic
2 Kilometers
USGS
science for a changing world


11-29-01
1815
2-4
500 meters
Moloka'i, Hawaii
1:20K Aerial Photography
November 29, 2001
USGS
science for a changing world


11-29-01
1815
3-3
500 meters
Moloka'i, Hawaii
1:20K Aerial Photography
November 29, 2001
USGS
science for a changing world


11-29-01
1815
3-5
500 meters
Moloka'i, Hawaii
1:20K Aerial Photography
November 29, 2001
USGS
science for a changing world


6 STATION
Model # 57161
Kodak
DISPLAY
MENU
RECORD
CAPTURE
REVIEW
CONNECT
INFO


K2-East Ex-0.5
2001/11/29 01:33

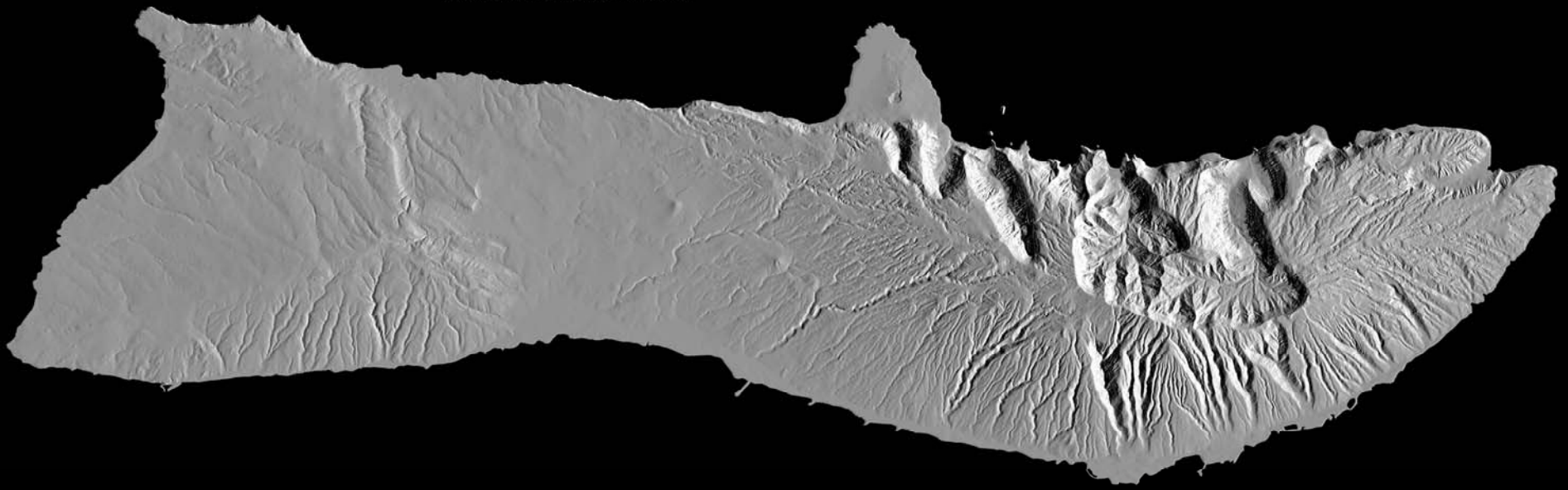

Hotel Molokai Ex-1.0
2001/12/3 10:01

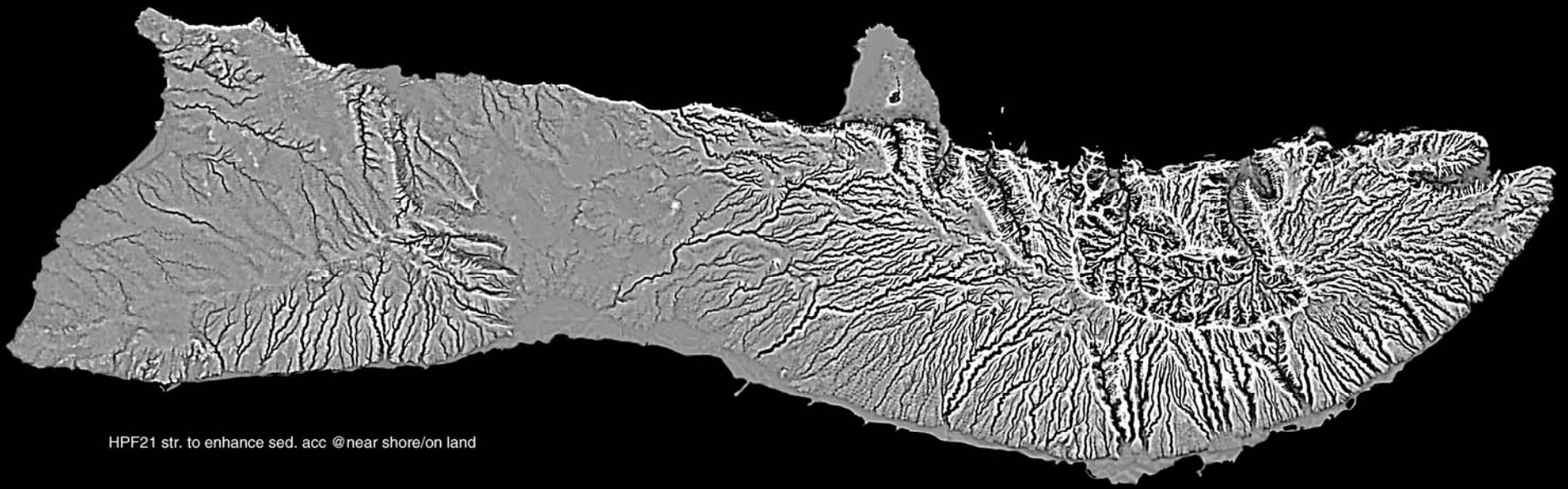

Hotel Molokai Ex-1.0
2001/12/12 10:01

Use of DEMs, soils, and vegetation cover information to study water erosion vulnerability

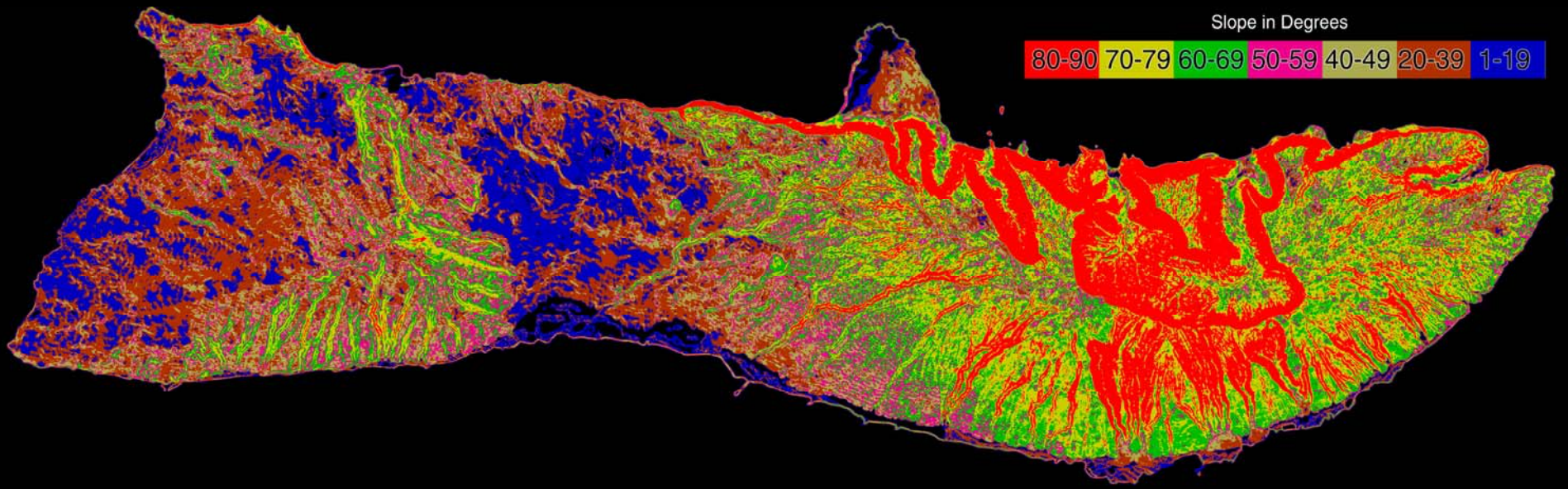
- DEMs for slope and drainage mapping
- USDA soils erodability map
- Landsat TM satellite images for annual vegetation dynamics
- Composite of these three variables

Moloka'i Shaded Relief

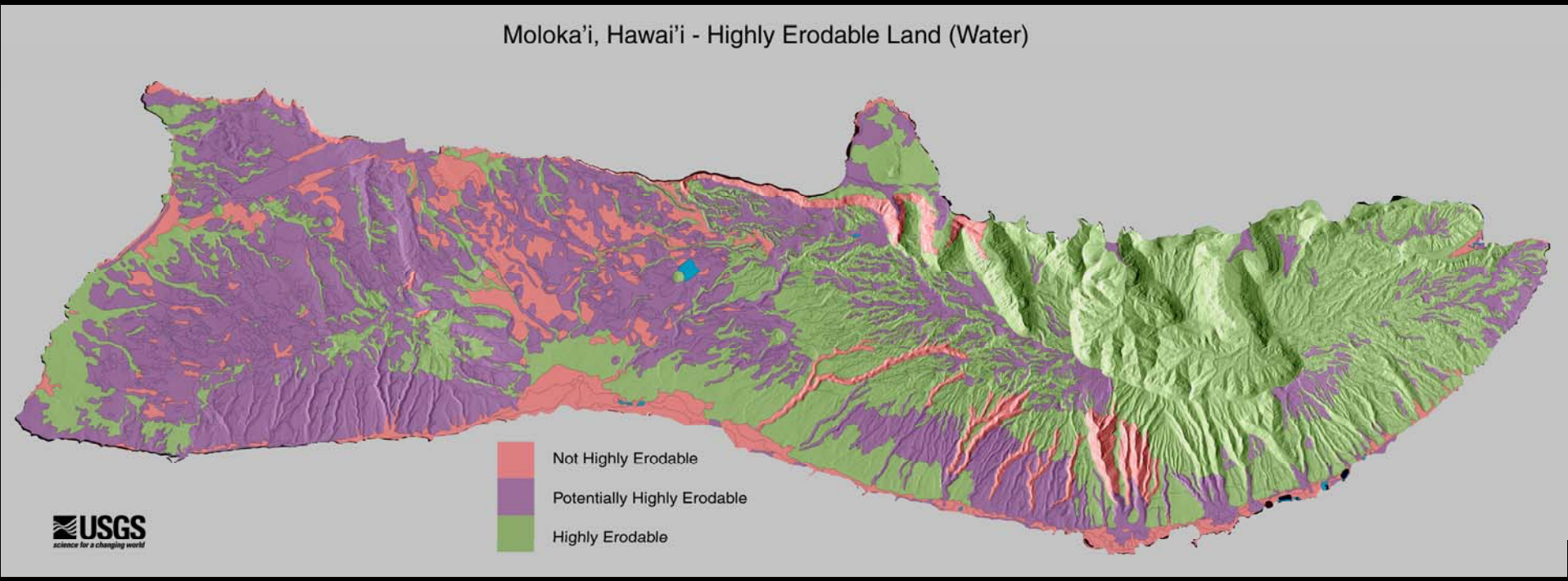


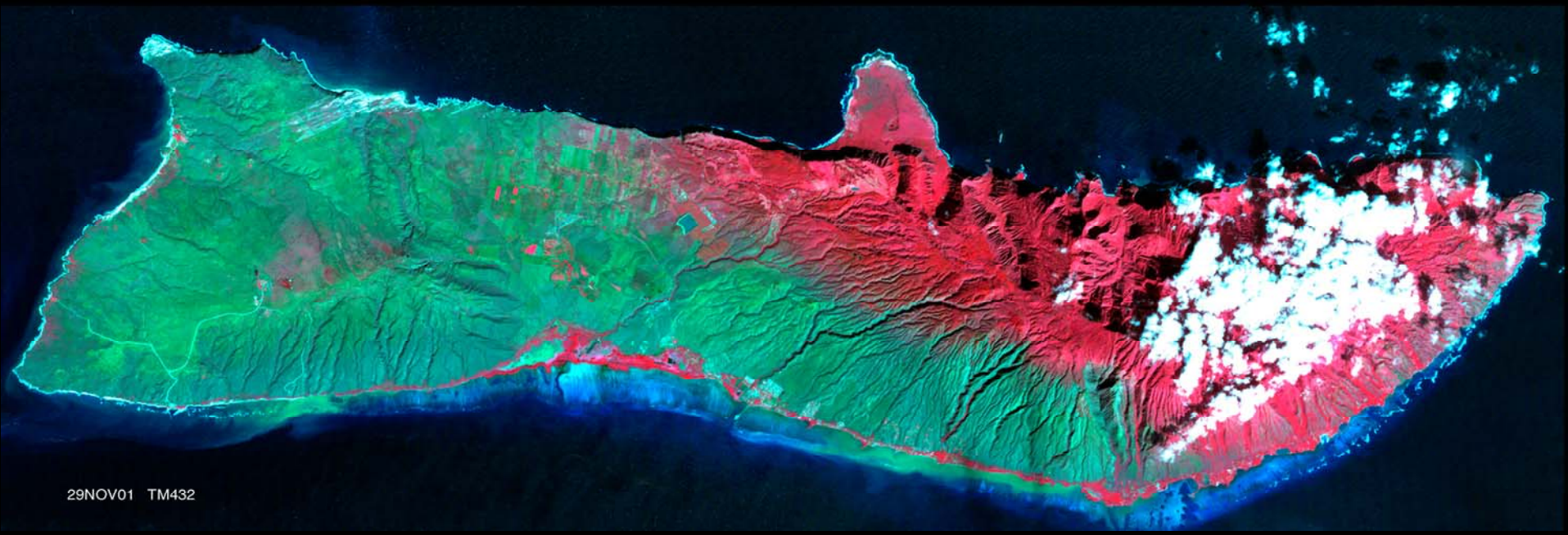


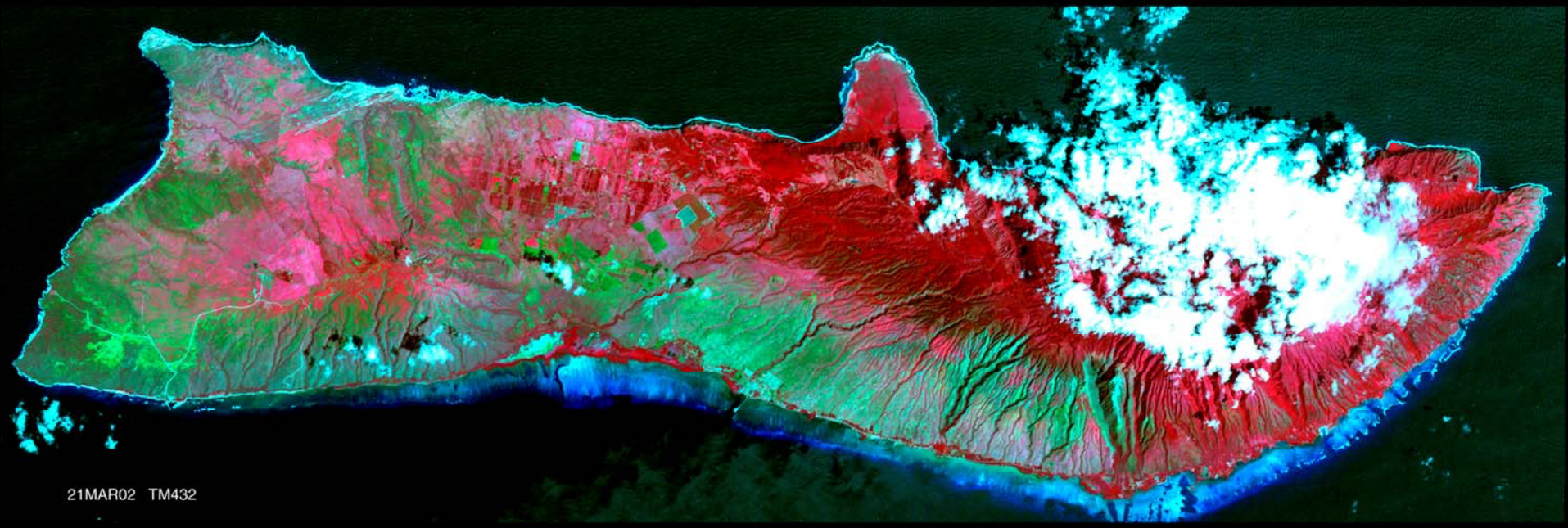
HPF21 str. to enhance sed. acc @near shore/on land

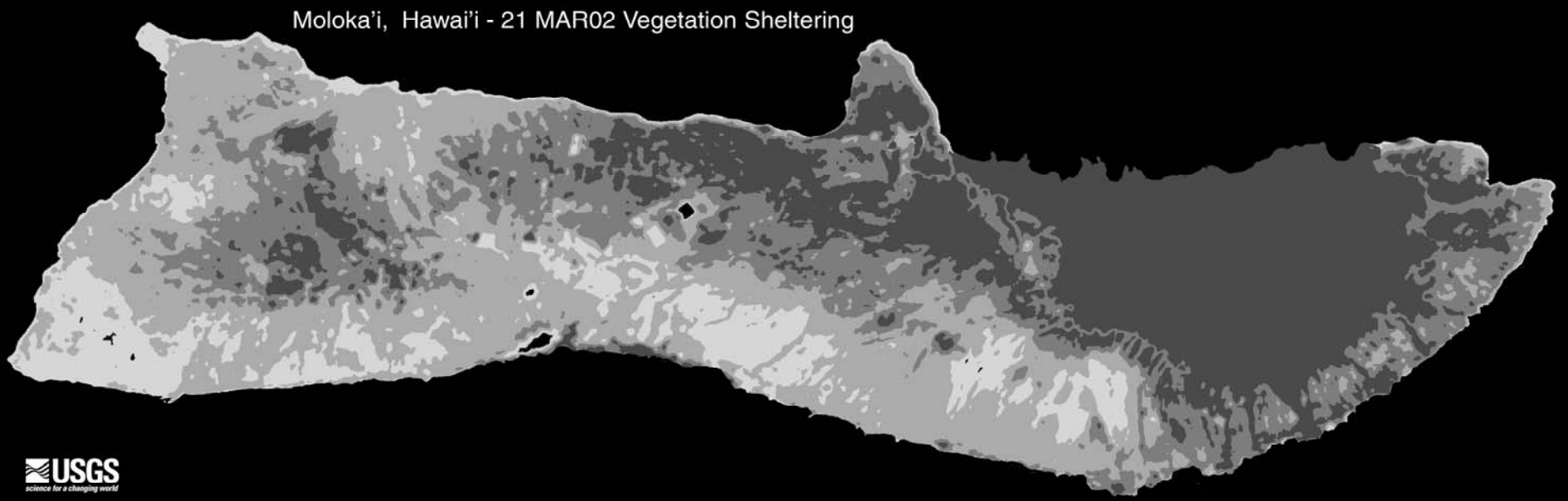

Slope in Degrees
80-90
70-79
60-69
50-59
40-49
20-39
1-19

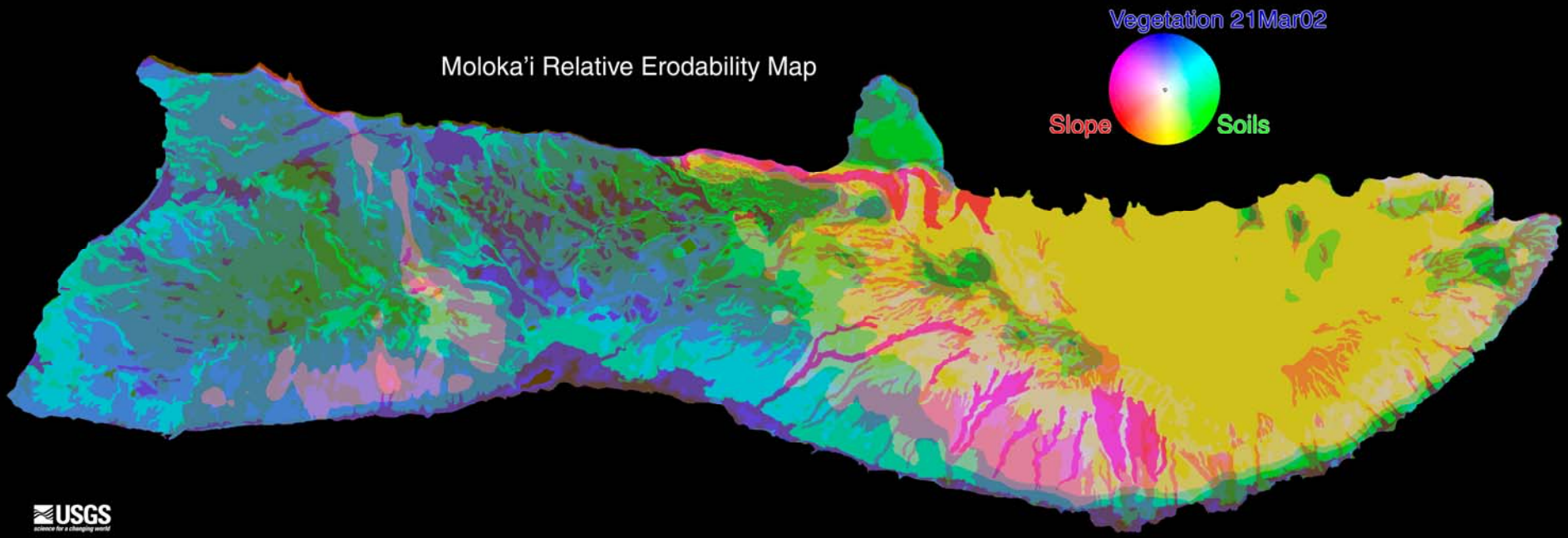
Moloka'i, Hawai'i - Highly Erodable Land (Water)




29NOV01 TM432


21MAR02 TM432


Moloka'i, Hawai'i - 21 MAR02 Vegetation Sheltering
USGS
science for a changing world

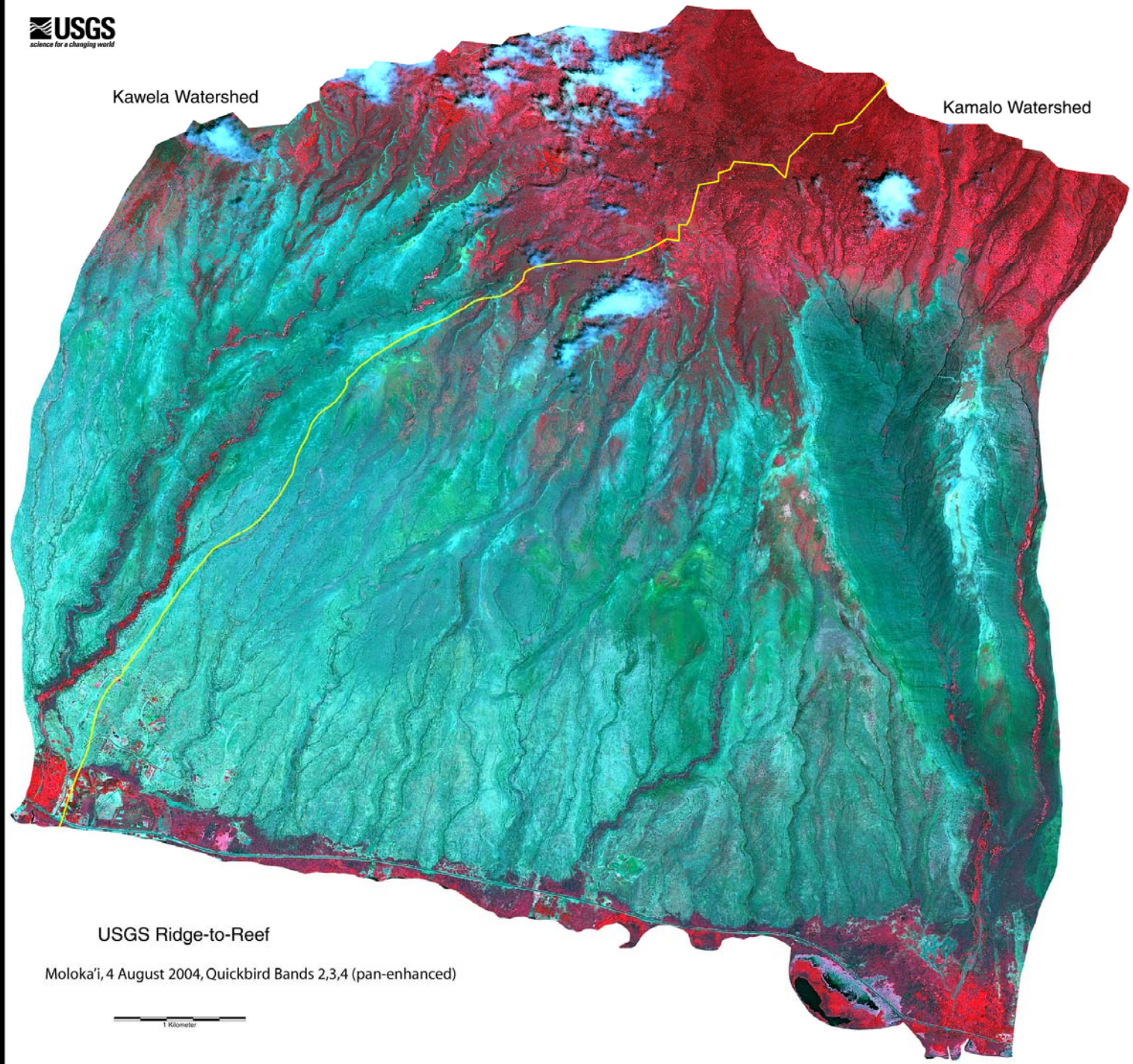

Moloka'i Relative Erodability Map
Vegetation 21Mar02
Slope
Soils
USGS
science for a changing world

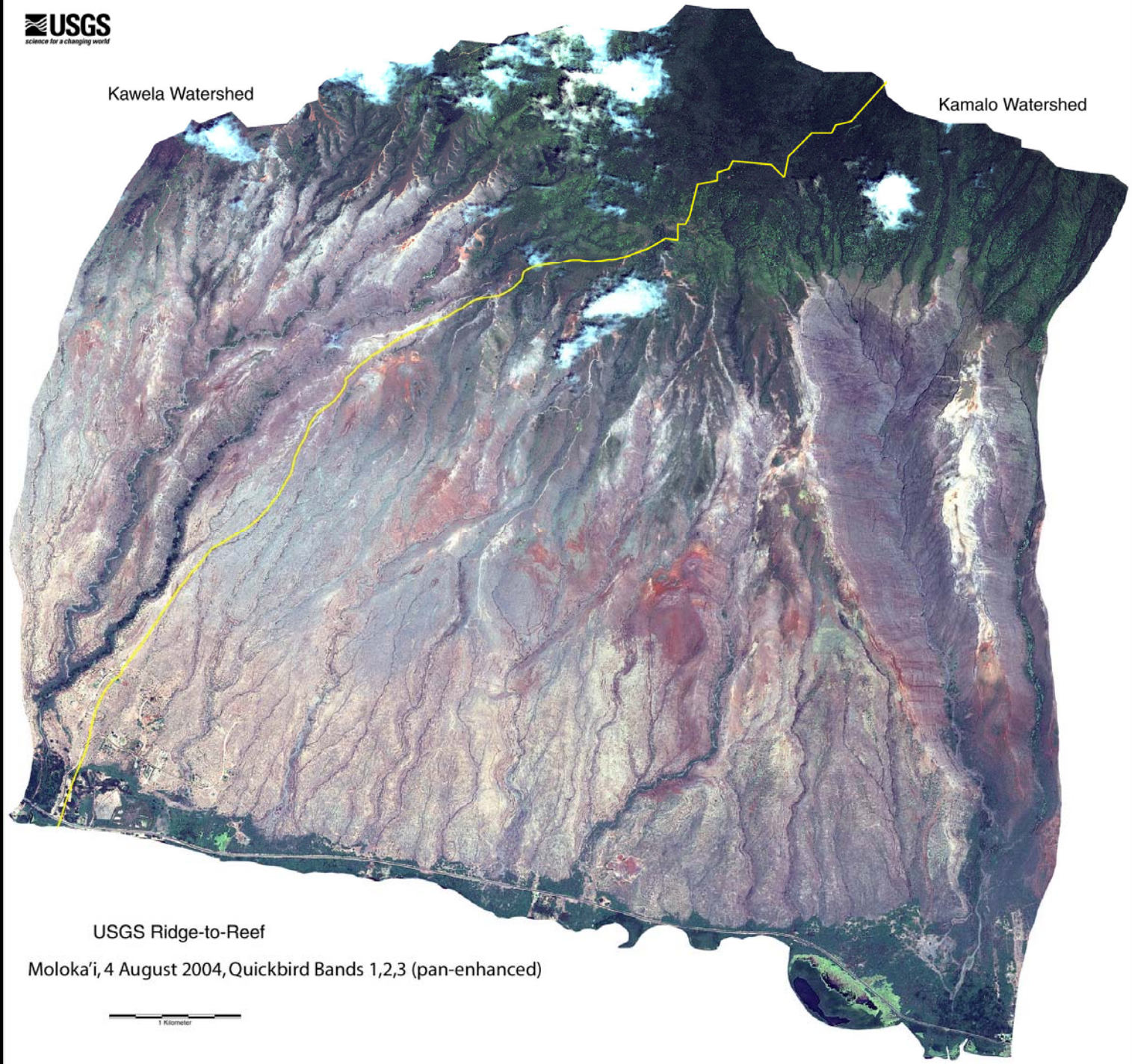
Use of high resolution Quickbird satellite images to study the Kawela and Kamalo watersheds on Moloka'i

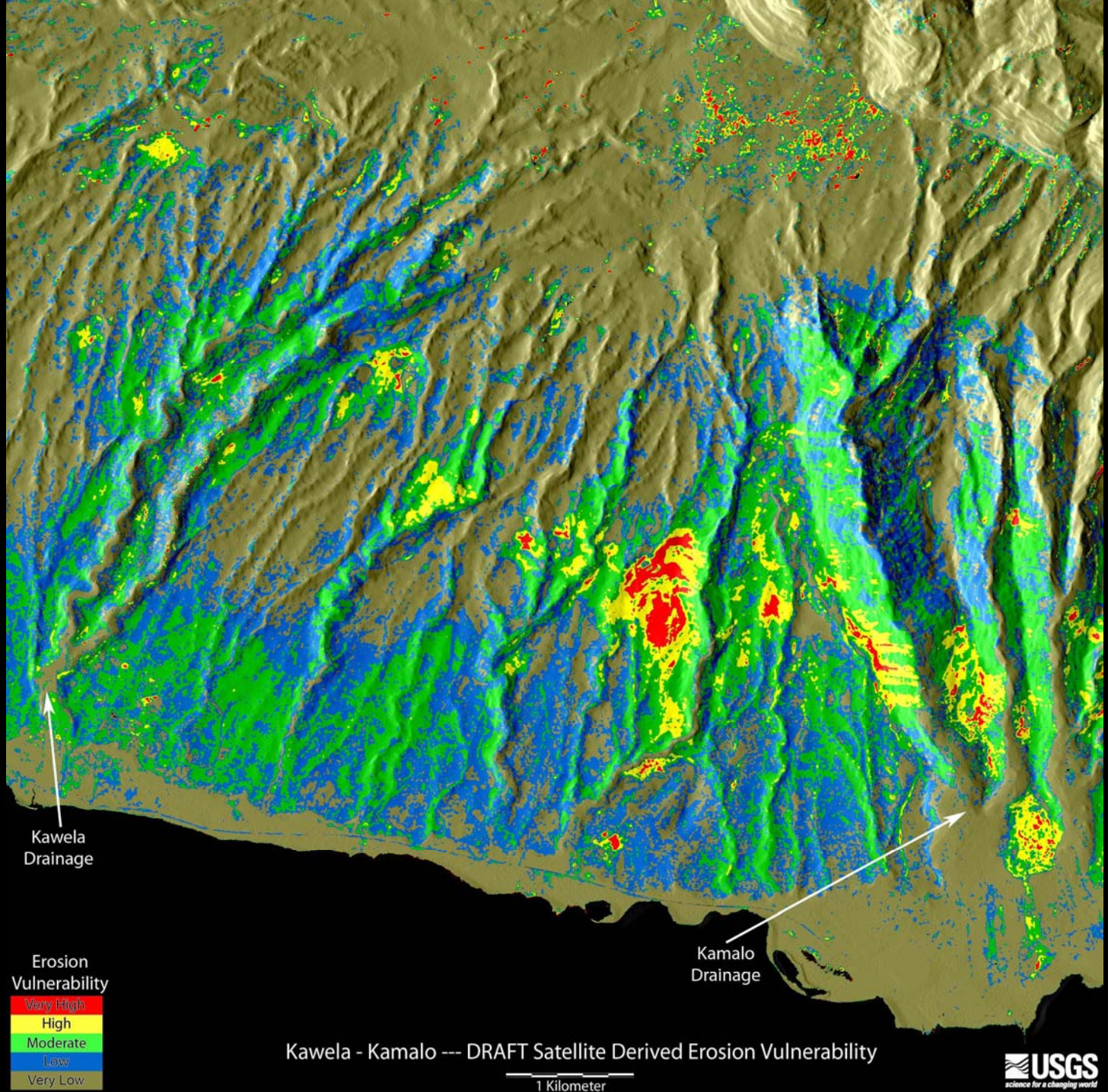
- Quickbird satellite image (0.6 and 2.5m resolution) showing the two watersheds, with zoomed in areas to show the full resolution of the image, including an area identified as a potential 'hotspot' sediment source

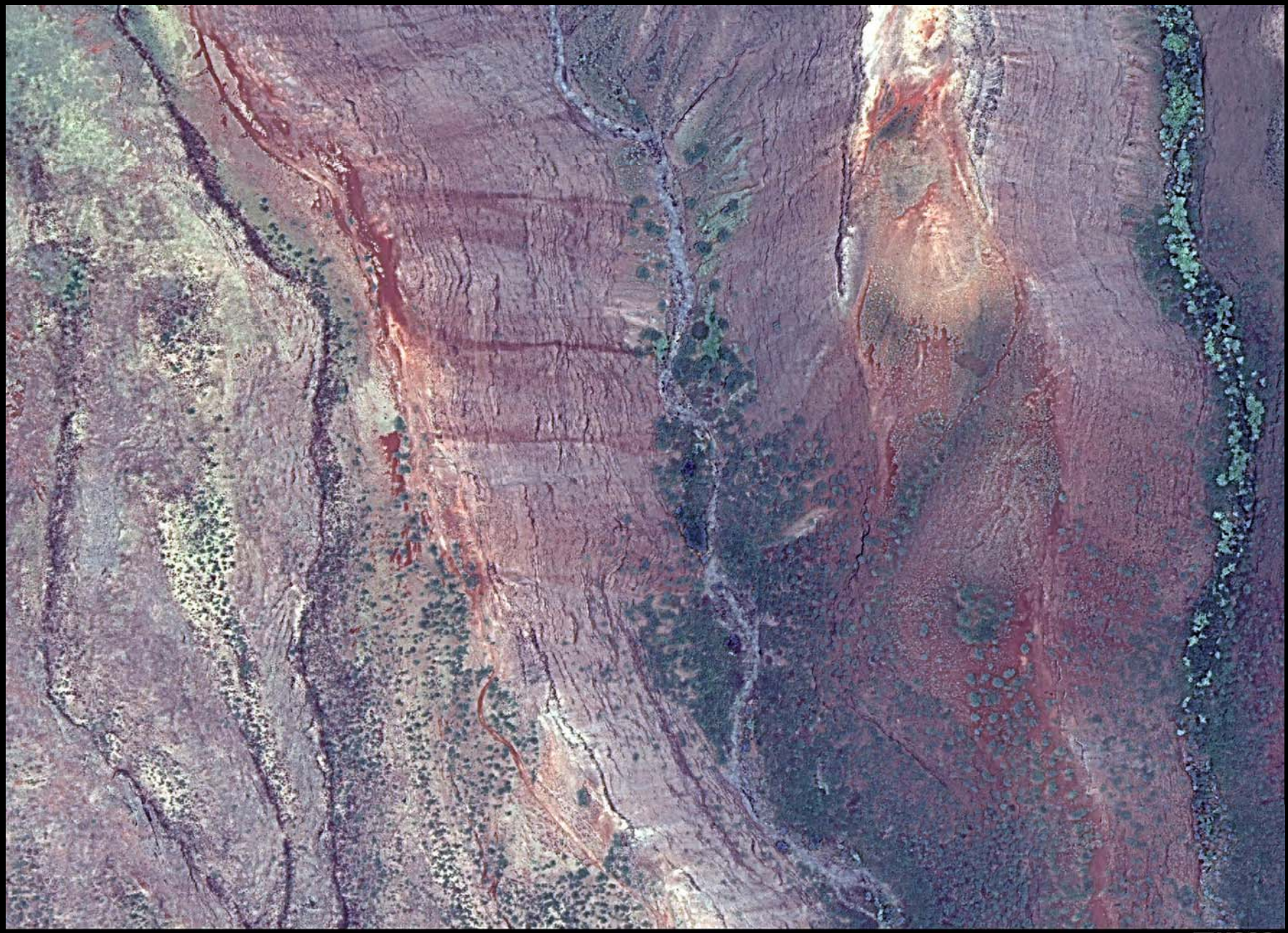
- DRAFT copy of a water erosion vulnerability map generated using only the Quickbird satellite image

- Percent perennial vegetation cover maps at different plot sizes generated using the Quickbird satellite image


USGS
science for a changing world
Kawela Watershed
Kamalo Watershed
USGS Ridge-to-Reef
Moloka'i, 4 August 2004, Quickbird Bands 2,3,4 (pan-enhanced)
1 Kilometer


USGS
science for a changing world
Kawela Watershed
Kamalo Watershed
USGS Ridge-to-Reef
Moloka'i, 4 August 2004, Quickbird Bands 1,2,3 (pan-enhanced)
1 Kilometer


Kawela
Drainage
Kamalo
Drainage
Erosion
Vulnerability
Very High
High
Moderate
Low
Very Low
Kawela - Kamalo --- DRAFT Satellite Derived Erosion Vulnerability
1 Kilometer
USGS
science for a changing world



100 Meters

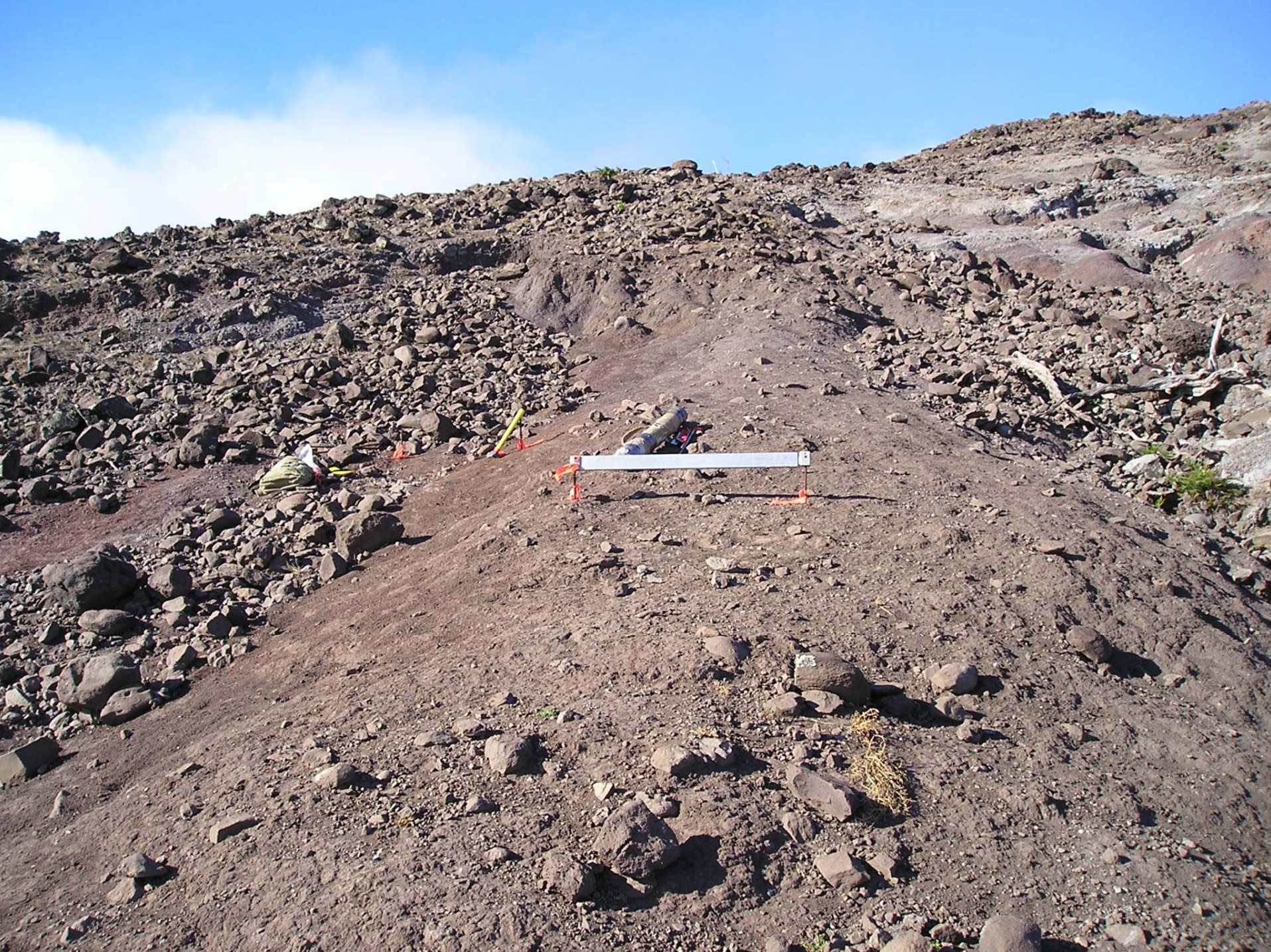
Quickbird Natural Color, 4 August 2004

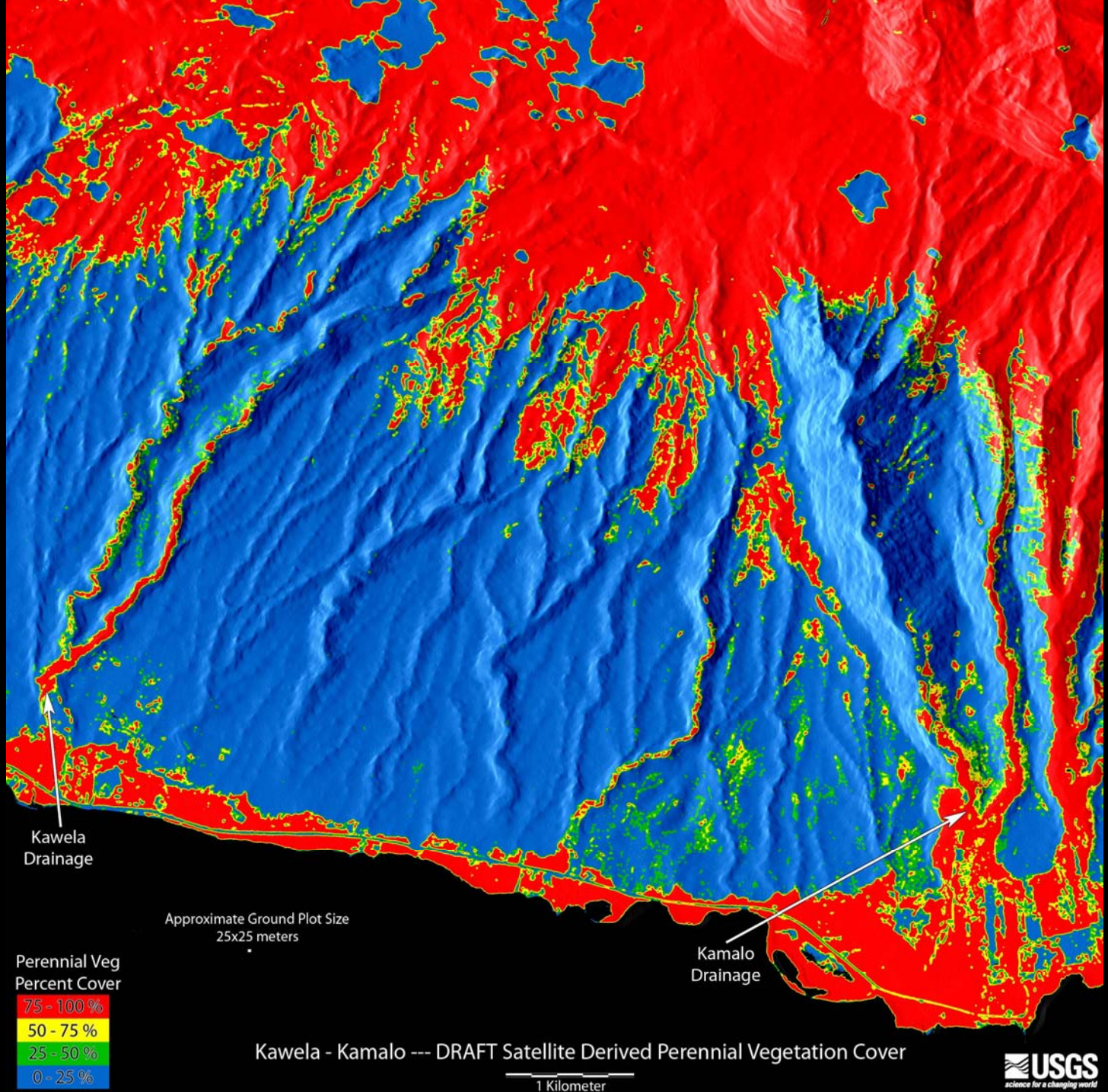
USGS
science for a changing world

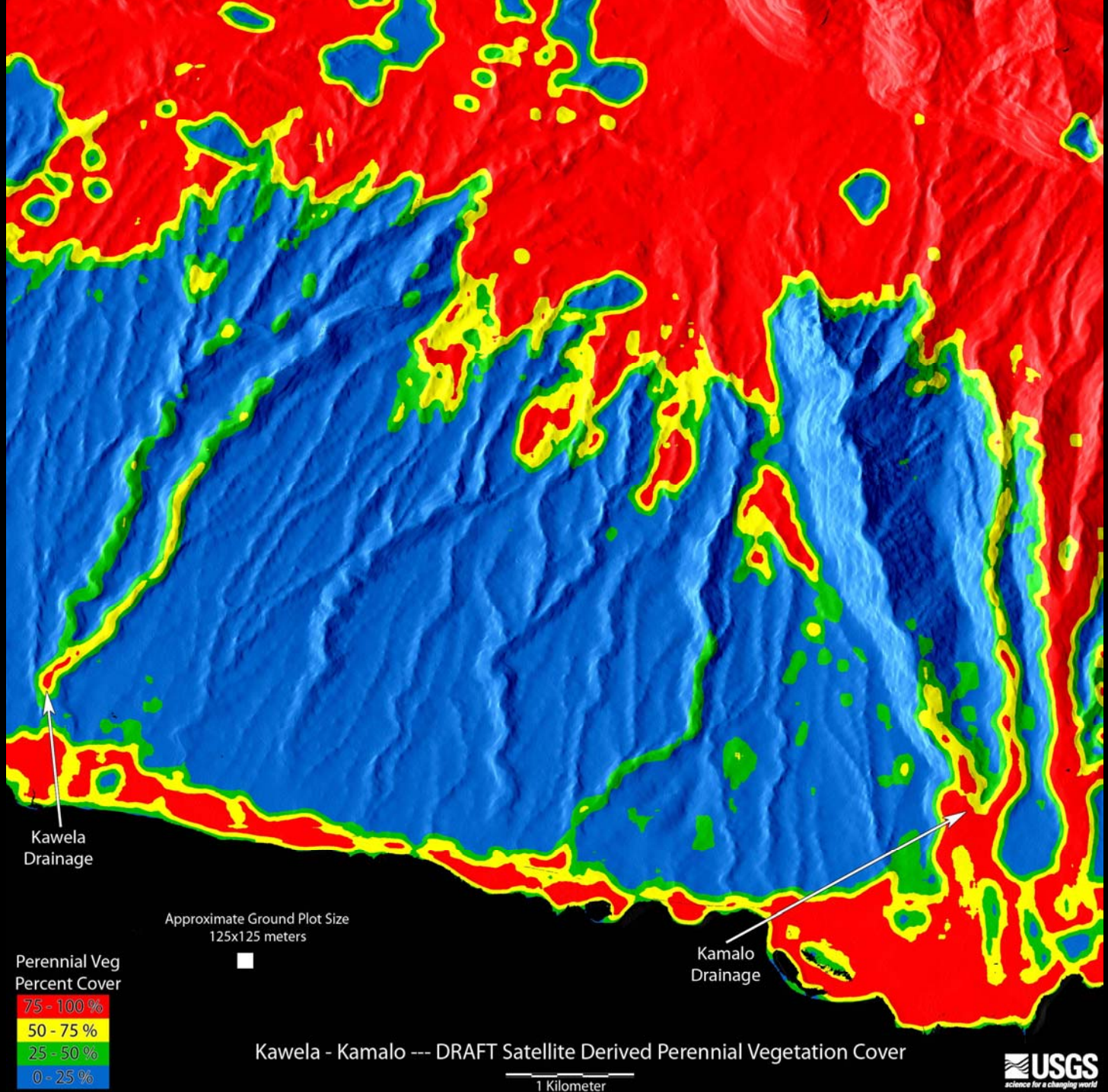
100 Meters

Quickbird Natural Color, 4 August 2004

USGS
science for a changing world



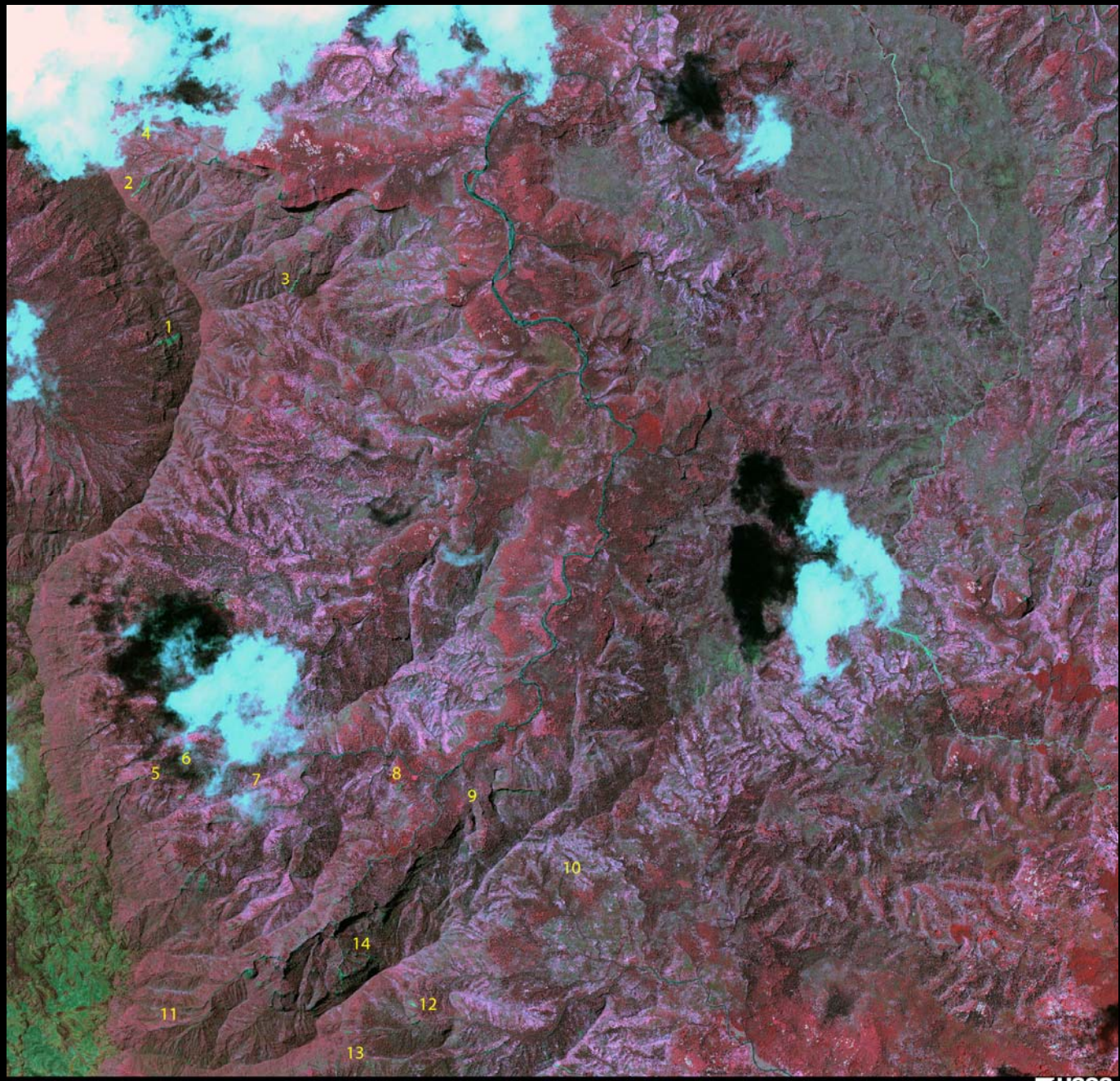

Kawela
Drainage
Approximate Ground Plot Size
25x25 meters
Kamalo
Drainage
Perennial Veg
Percent Cover
75 - 100 %
50 - 75 %
25 - 50 %
0 - 25 %
Kawela - Kamalo --- DRAFT Satellite Derived Perennial Vegetation Cover
1 Kilometer
USGS
science for a changing world


Kawela
Drainage
Kamalo
Drainage
Approximate Ground Plot Size
125x125 meters
Perennial Veg
Percent Cover
75 - 100 %
50 - 75 %
25 - 50 %
0 - 25 %
Kawela - Kamalo --- DRAFT Satellite Derived Perennial Vegetation Cover
1 Kilometer
USGS
science for a changing world

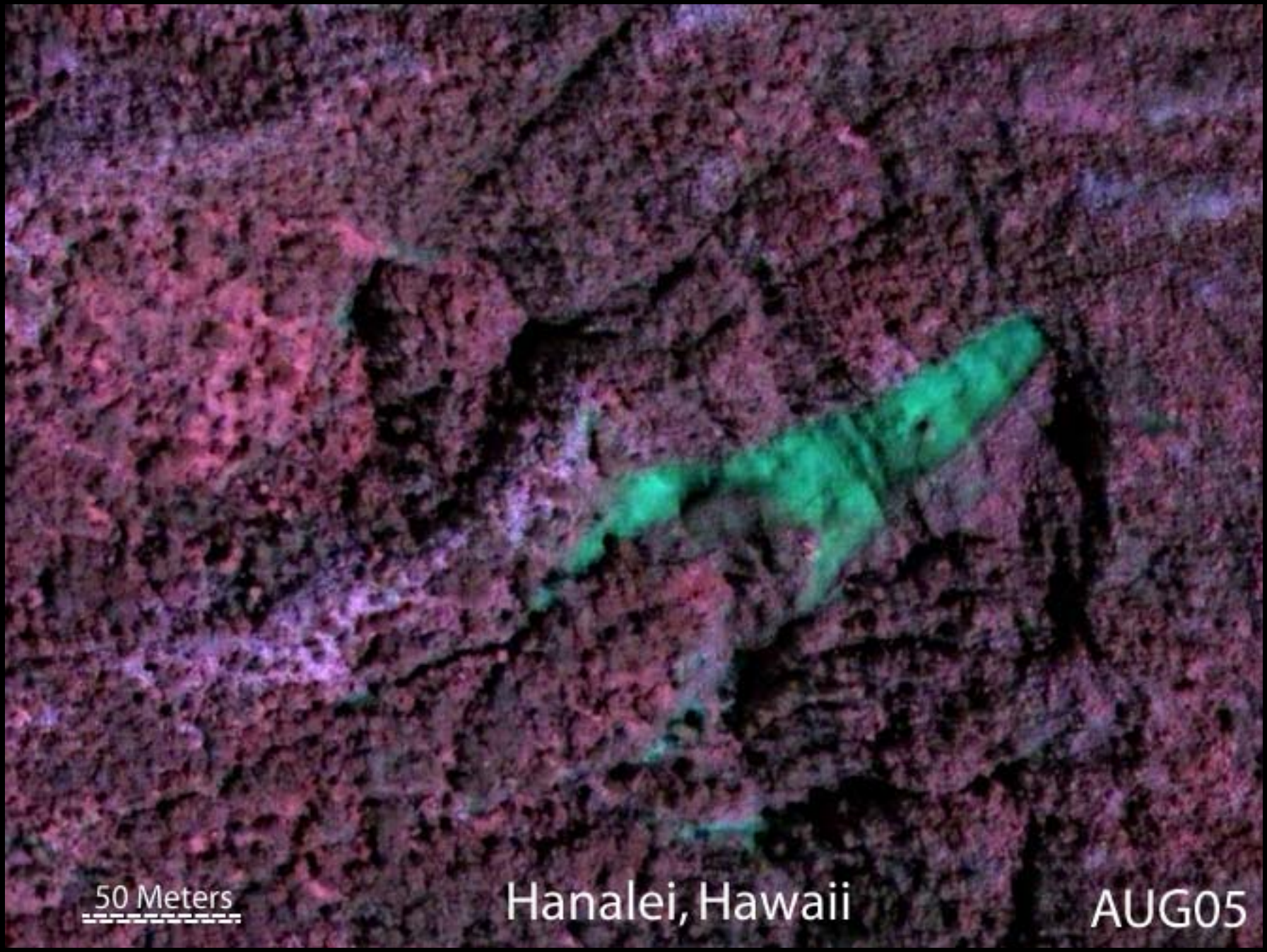
Use of high resolution Quickbird satellite images and USGS airborne imaging system to detect landslides and do vegetation mapping in the Hanalei watershed

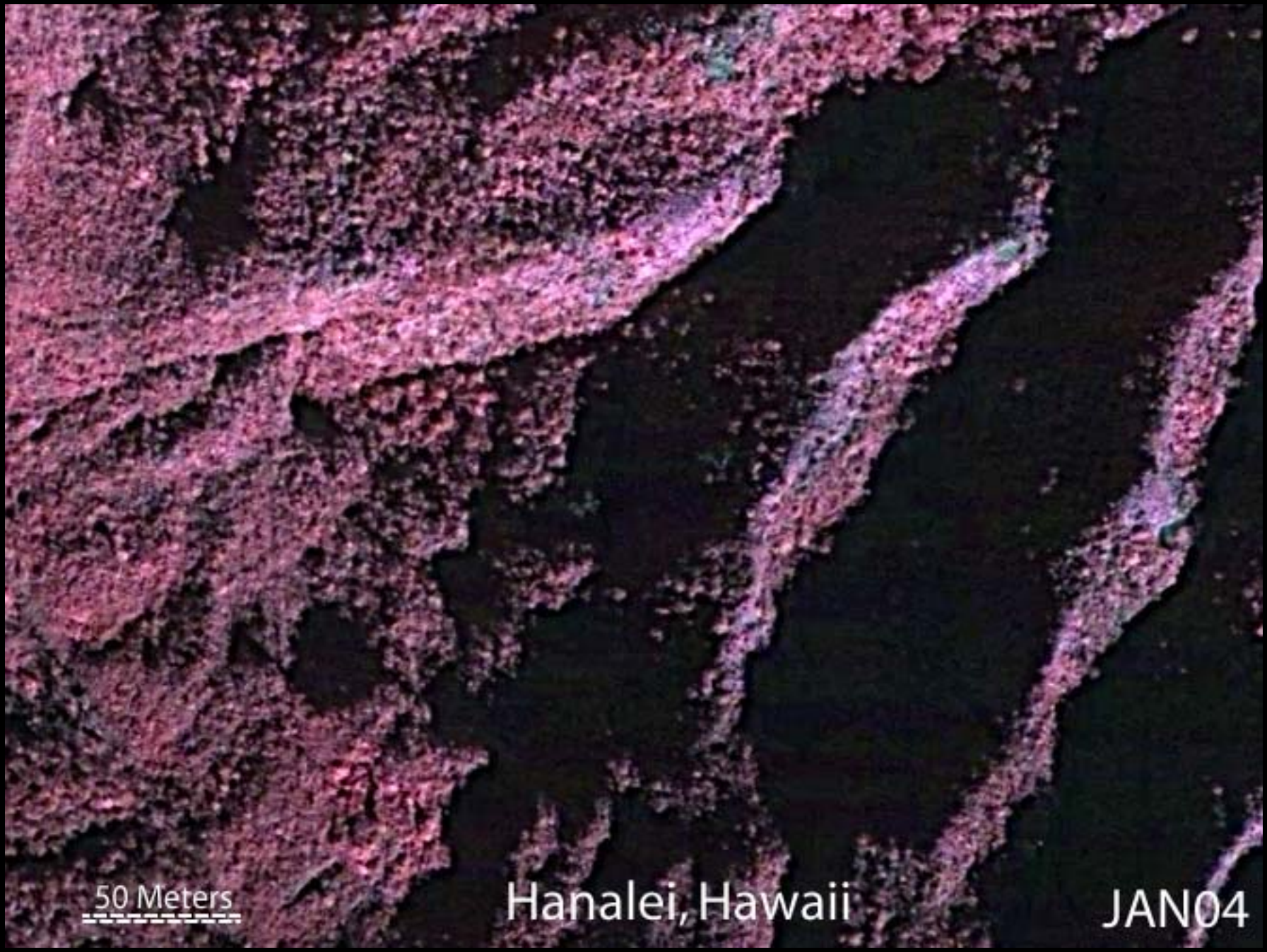
- Quickbird satellite images collected on January 2004 and August 2005 are being used to detect *new* landslides and to help map vegetation (with Jim Jacobi in BRD)

- USGS airborne imaging system turned sideways to image the steep cliffs to help with both landslide detection and vegetation mapping (with Jim Jacobi in BRD)


4
2
3
1
5
6
7
8
9
10
14
11
12
13
1 Kilometer
USGS Ridge to Reef ---- Hanalei Watershed, Kaua'i Quickbird Color Infrared - 25 August 2005
USGS
science for a changing world


50 Meters
Hanalei, Hawaii
JAN04


50 Meters
Hanalei, Hawaii
AUG05

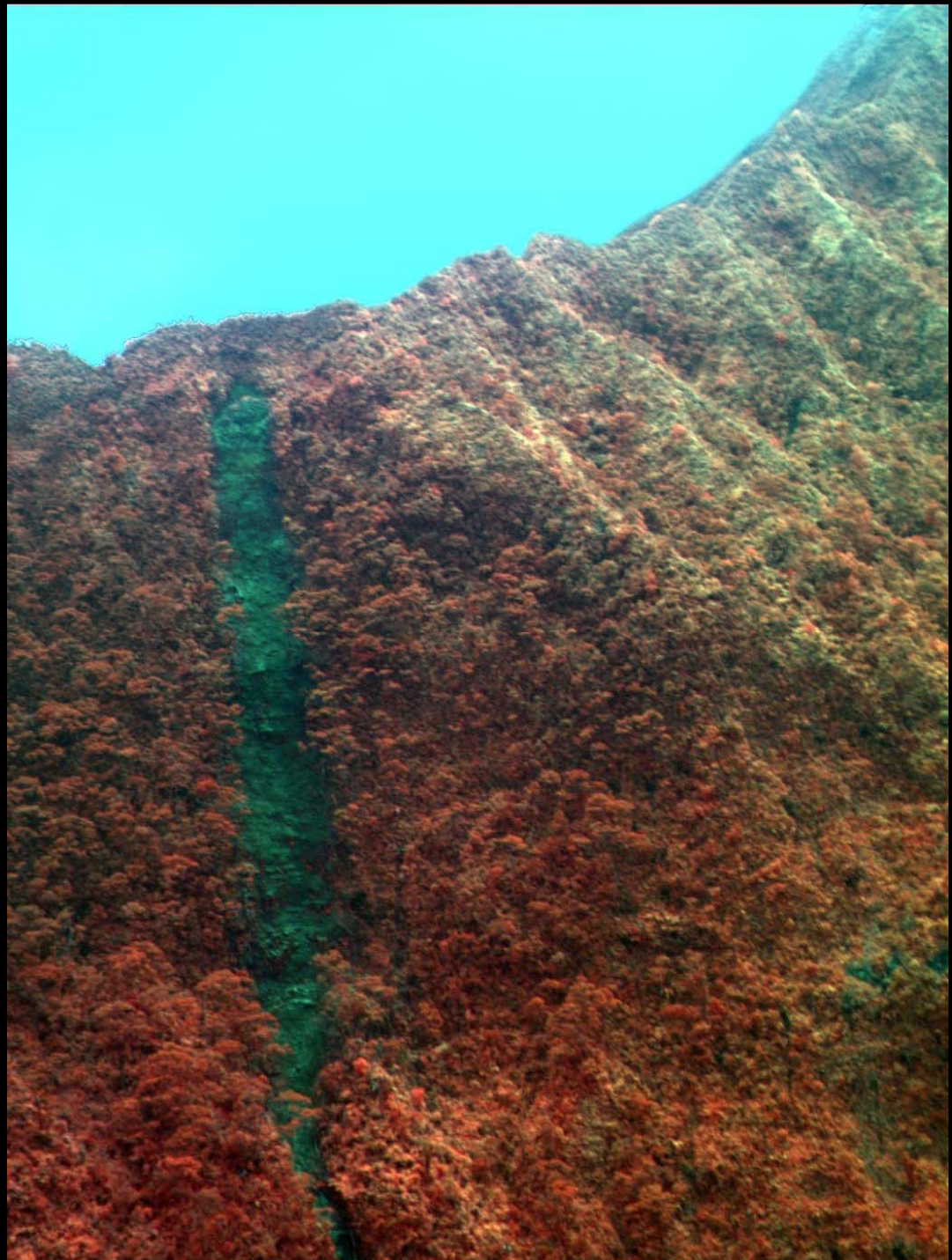

50 Meters
Hanalei, Hawaii
JAN04


50 Meters
Hanalei, Hawaii
AUG05

USGS Airborne Digital Imaging System
Hanale'i, Kaua'i August 2004


USGS Airborne Digital Imaging System
Hanale'i, Kaua'i August 2004


2003 09 08 15:26
Hanale'i Watershed



Hanale'i Watershed

Investigating the use of spectral radiometers to detect and monitor suspended sediment on the Hanalei river

- A spectral radiometer was installed next to an existing WRD gauge station on the Hanalei river during the latter part of fy04

- Spectral measurements are taken every 15 minutes during daylight hours. The objective is to correlate the spectral values with the suspended sediment concentration values derived from the WRD water sampling (with Barry Hill in WRD)

- A second spectral radiometer was recently installed at the Kawela drainage next to the new WRD gauge station.


USGS Spectral Radiometer Station
2004 06 15 13:18


USGS Spectral Radiometer Station
2004 06 15 13:43

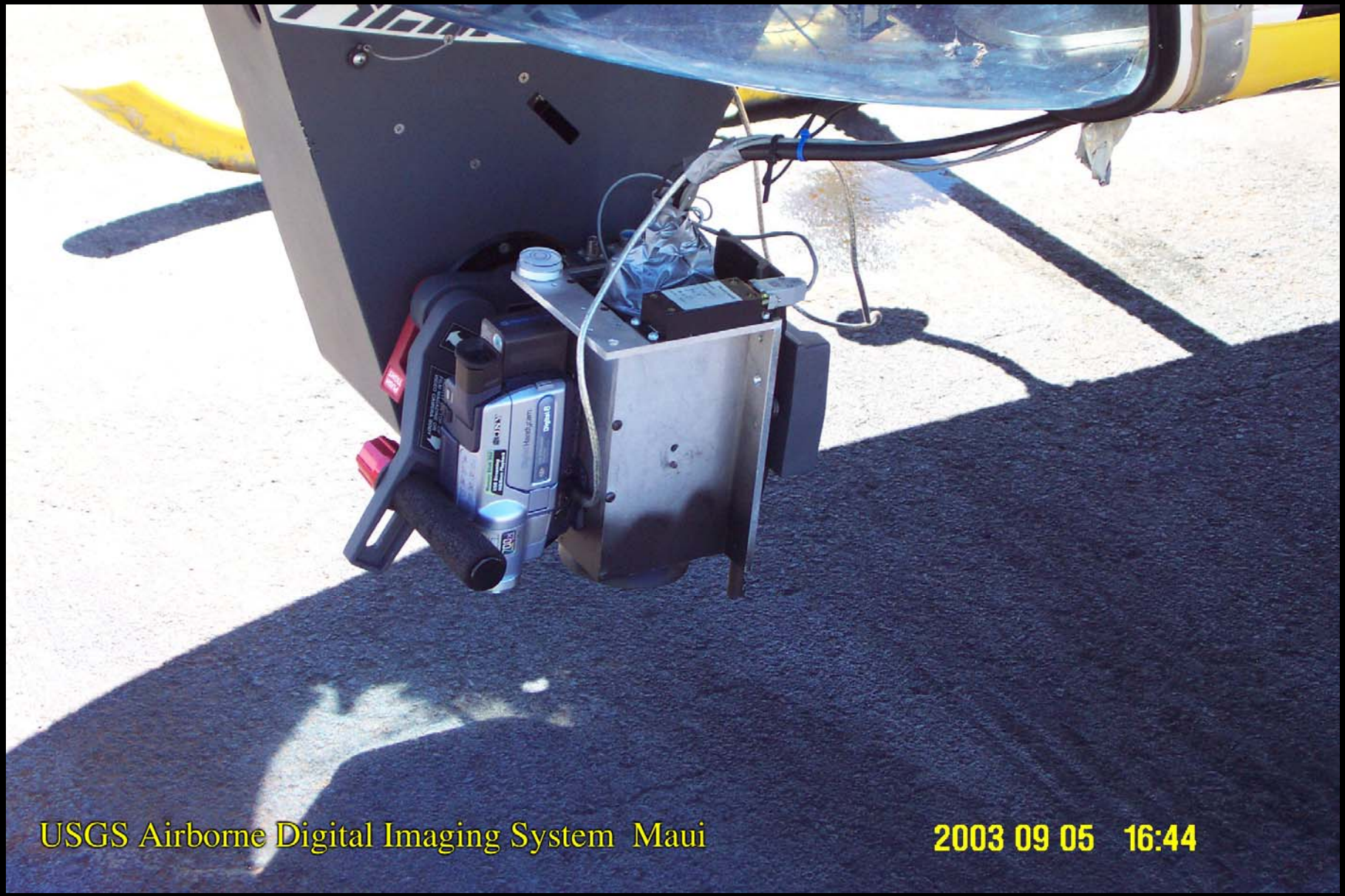

USGS Spectral Radiometer Station
2004 06 15 14:52

USGS airborne digital imaging system

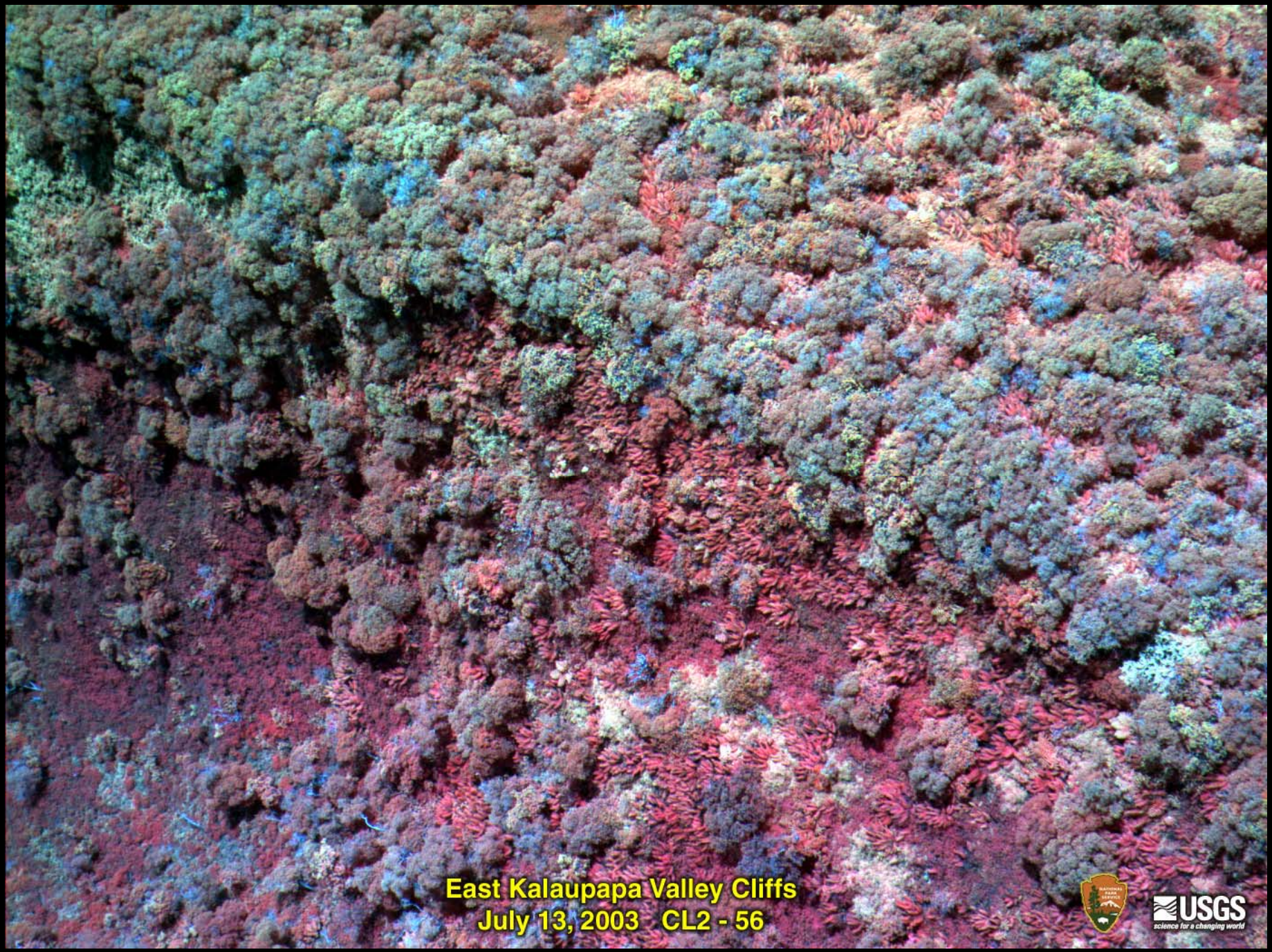
- Mounted on a helicopter ready to do some imaging within the National Parks and NWRs on Maui and Moloka'i, as well as along the southern coast of Moloka'i

- Sample images at Kalaupapa National Park on north Moloka'i and the NWR on Maui


N98D
USGS Airborne Digital Imaging System Maui
2003 09 05 16:43

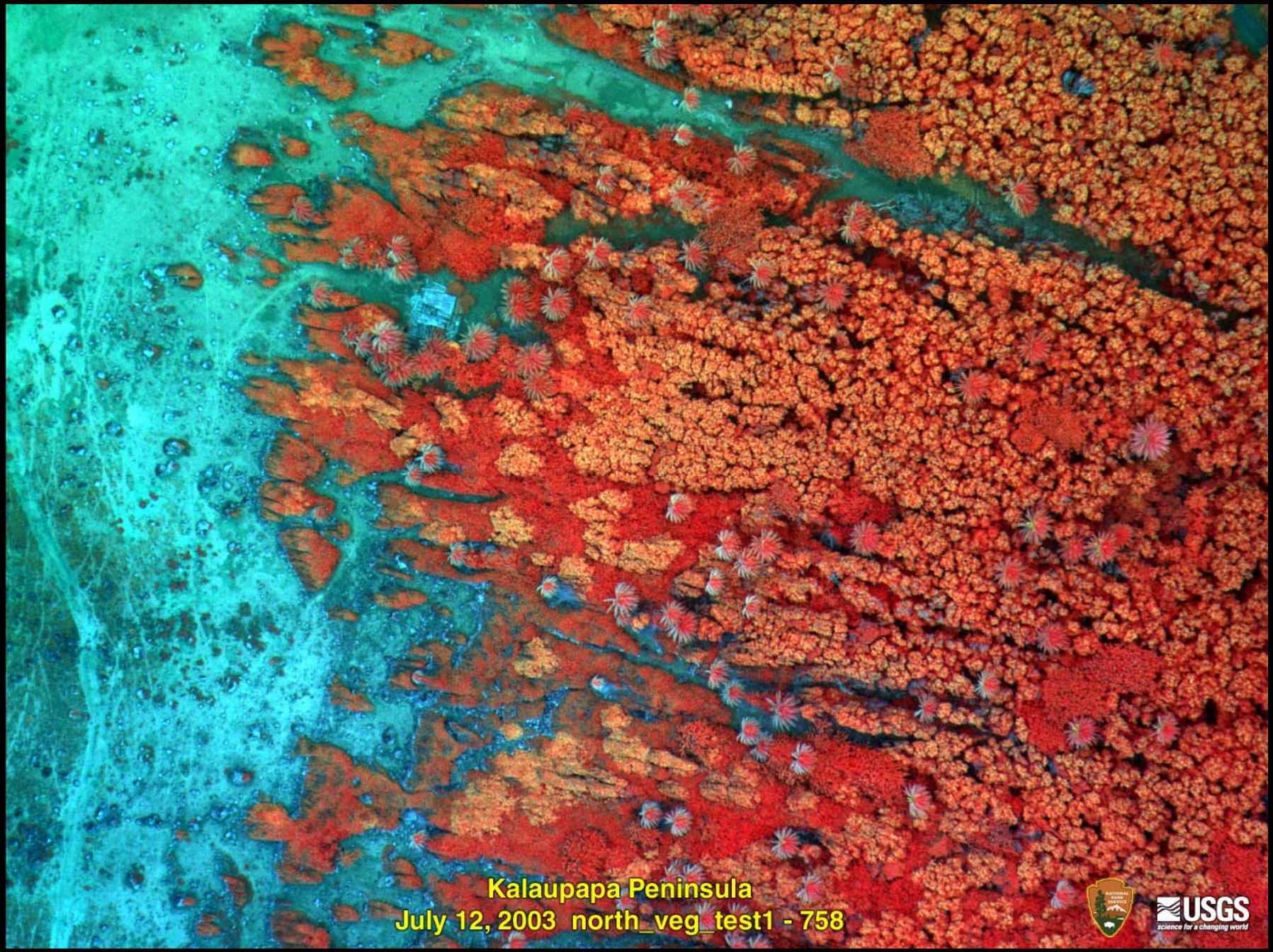

USGS Airborne Digital Imaging System Maui
2003 09 05 16:44

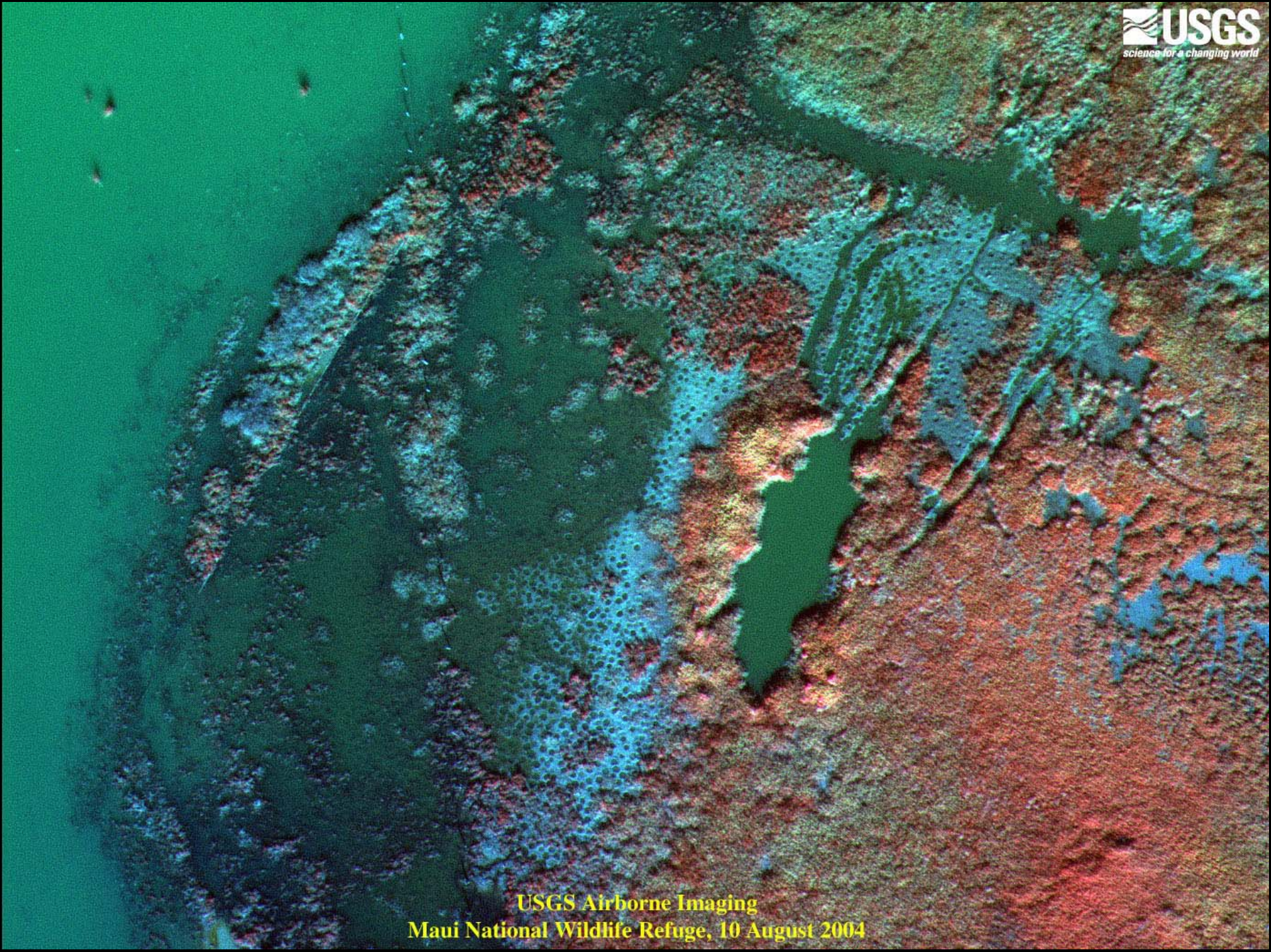

Power 300
DELL


East Kalaupapa Valley Cliffs
July 13, 2003 CL2 - 56
USGS
science for a changing world


2003 07 13 13:13


East Kalaupapa Valley Cliffs
July 13, 2003 CL2 - 191
USGS
science for a changing world


Kalaupapa Peninsula
July 12, 2003 north_veg_test1 - 758
USGS
science for a changing world


USGS
science for a changing world
USGS Airborne Imaging
Maui National Wildlife Refuge, 10 August 2004

USGS airborne digital imaging system radiometric calibration

- One of the issue with any imaging system is the radiometric calibration. The following slide shows the calibration file we generated for each of the three spectral bands to correct for camera radiometric distortions. The calibration files were generated using digital photos/images of national standard flat plate panels.

Blue - Green | Red | Near Infrared

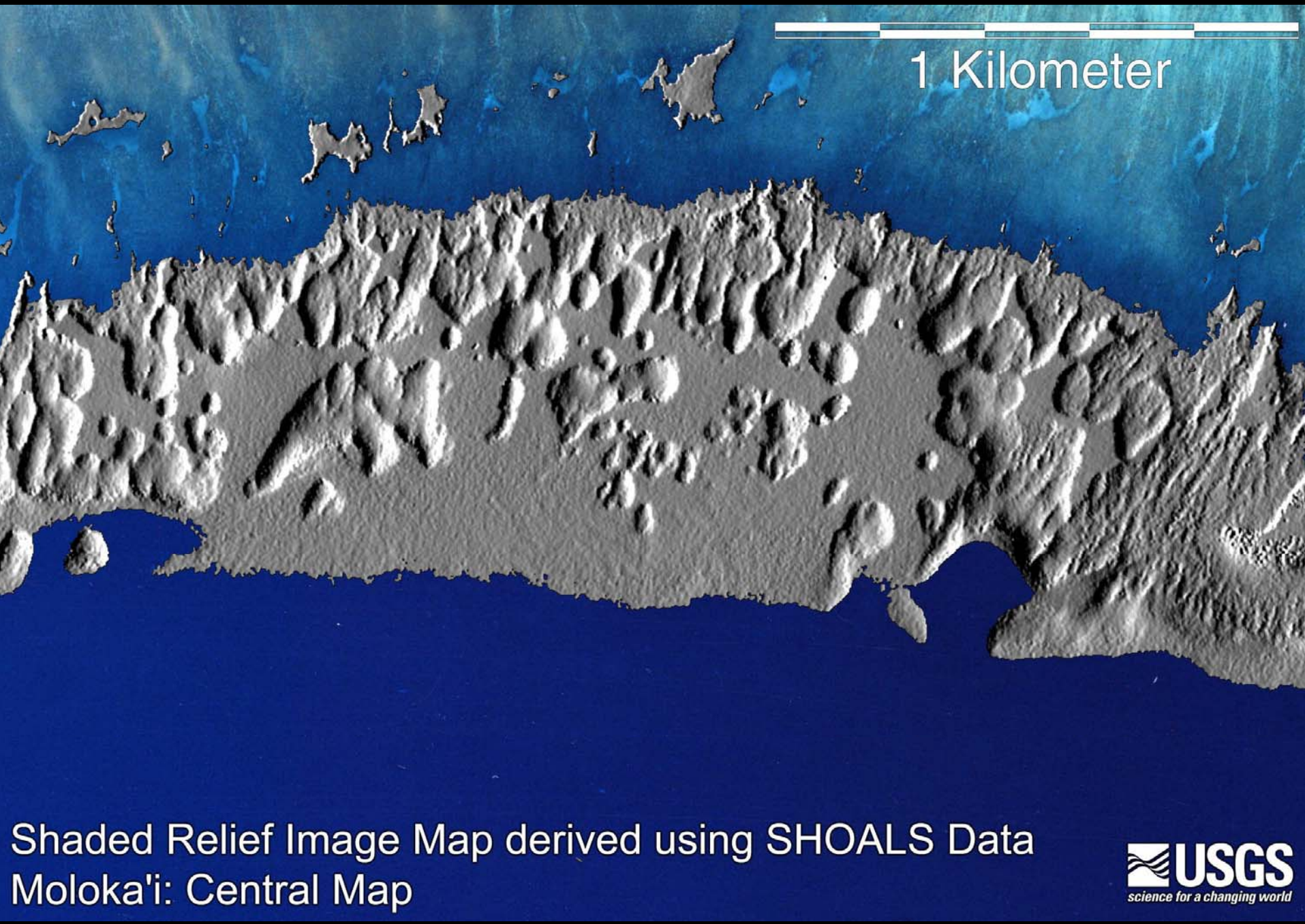
Radiometric Calibration Files

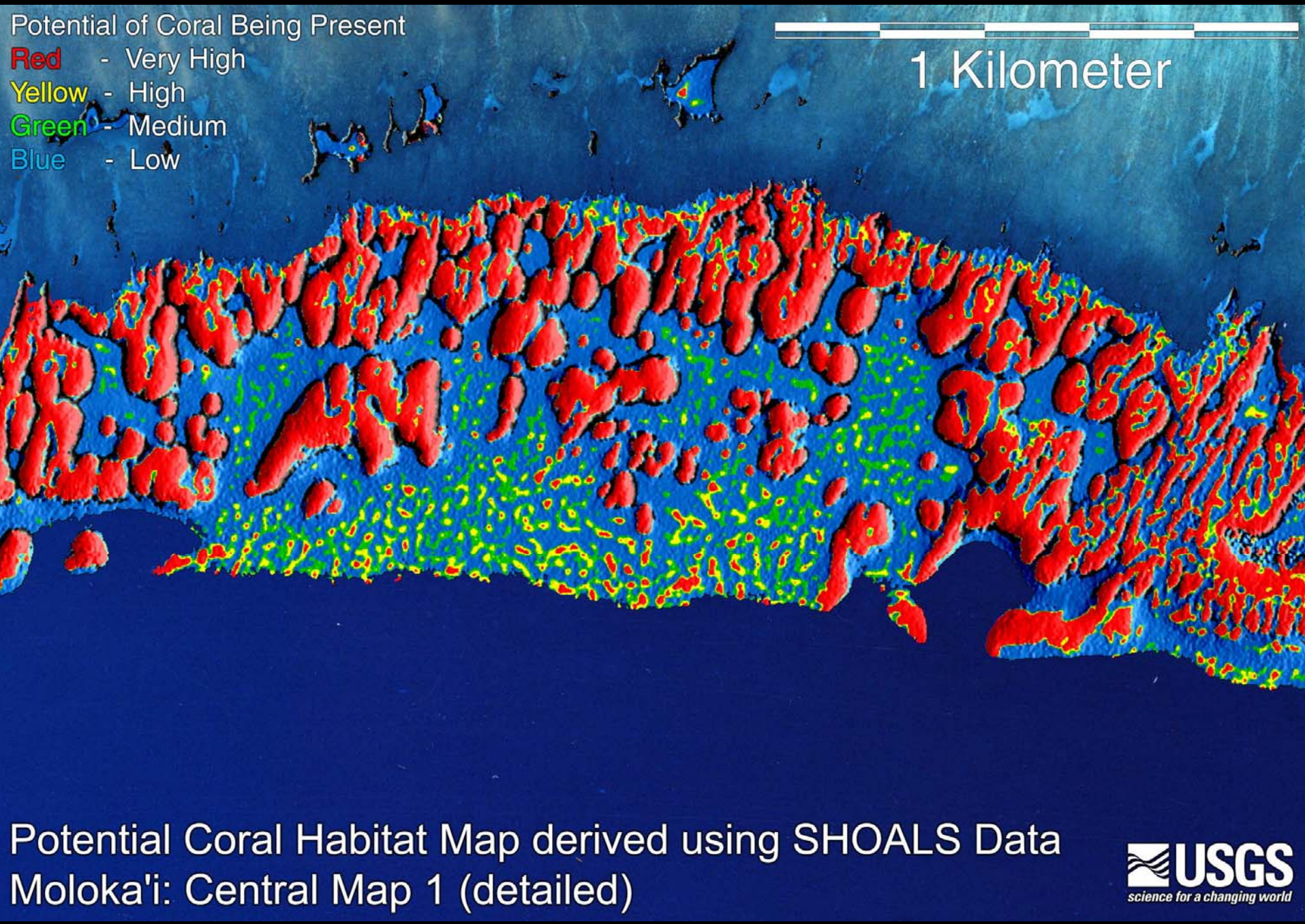
SHOALS airborne bathymetry of the coral reef

- We have been involved with GD's Coastal and Marine Geology project to study the coral reef at Moloka'i for six years.

- One of the issues of sedimentation is the impact of on-land runoff onto the coral reef habitat.

- Besides using very-high resolution aerial imaging and/or photographs (6 to 12 inch pixels) the SHOALS airborne lidar system was used to collect detailed bathymetry of the coral reef on the southern coastal waters of Moloka'i.


1 Kilometer
Shaded Relief Image Map derived using SHOALS Data
Moloka'i: Central Map
USGS
science for a changing world



Potential Coral Habitat Map derived using SHOALS Data
Moloka'i: Central Map 1 (detailed)

USGS
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Shaded Relief Image Map derived using SHOALS Data
Moloka'i : Central Map

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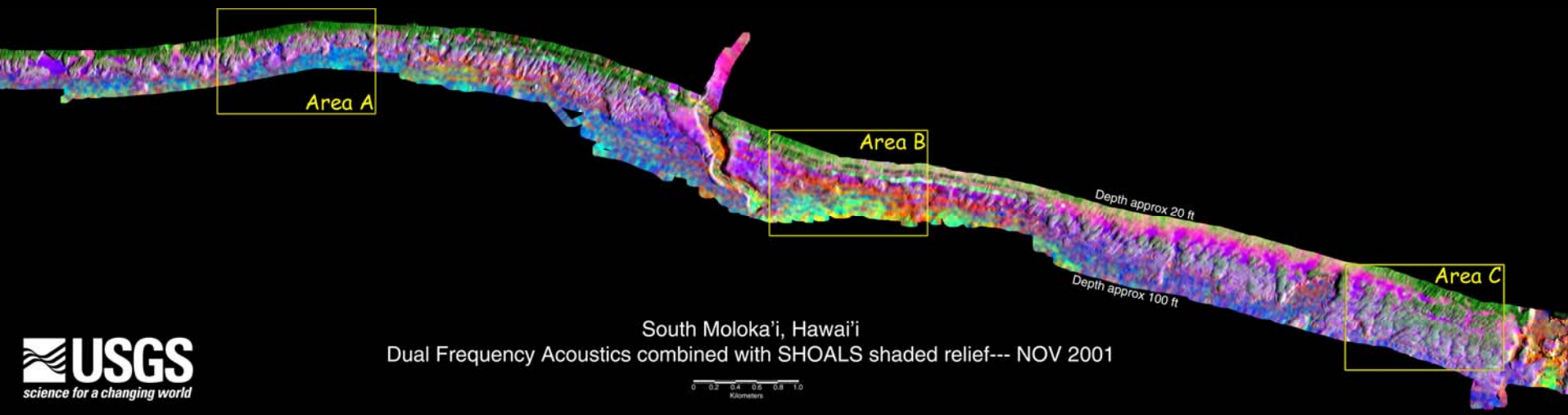
Acoustic survey of the coral reef

• In general, optical imaging (regardless of the number of bands) does not have enough spectral information at water depths greater than 30 to 40 feet (even in the very-clear coastal waters of Hawai'i) to allow coral type identification. You can 'see' sand vs hard rock to about 90 to 100 feet, but that is the limit of information that can be extracted.

• Within our task in the GD Coastal and Marine Geology project to study the coral reef at Moloka'i we used two acoustic frequency profiling systems in water depths ranging between 15 to 150 feet to investigate this type of remote sensing to help map in deeper waters.



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South Moloka'i, Hawai'i
Dual Frequency Acoustics combined with SHOALS shaded relief--- NOV 2001

0 0.2 0.4 0.6 0.8 1.0
Kilometers

Ground-Truthing: Remote Sensing Style

• Marine geologist and biologist are usually excellent divers, geographers and remote sensing scientist are often land-lovers. So what to do about ground-truthing airborne lidar and acoustics data sets?

• We used a ‘digital drop-down video camera system’ that allowed us to collect ‘up close’ information about what is at particular locations of interest. We collected digital video using this system at approximately 500 locations ranging in water depths from 15 to 120 feet.


2003 02 10 14:04


2003 02 10 14:04


2003 02 12 16:48


2003 02 10 14:04

Collaborators

USGS Ridge-to-Reef (all disciplines)

- Geology --- coral reef
- Water --- on-land runoff
- Biology --- vegetation (mapping and monitoring)
- Geography --- all of the above/excellent opportunity
- Western Region Associate Director's Office

Non-USGS

- NPS, FWS, USDA, and EPA
- University of Hawai'i
- NGOs (TNC and Hanalei Watershed Hui)


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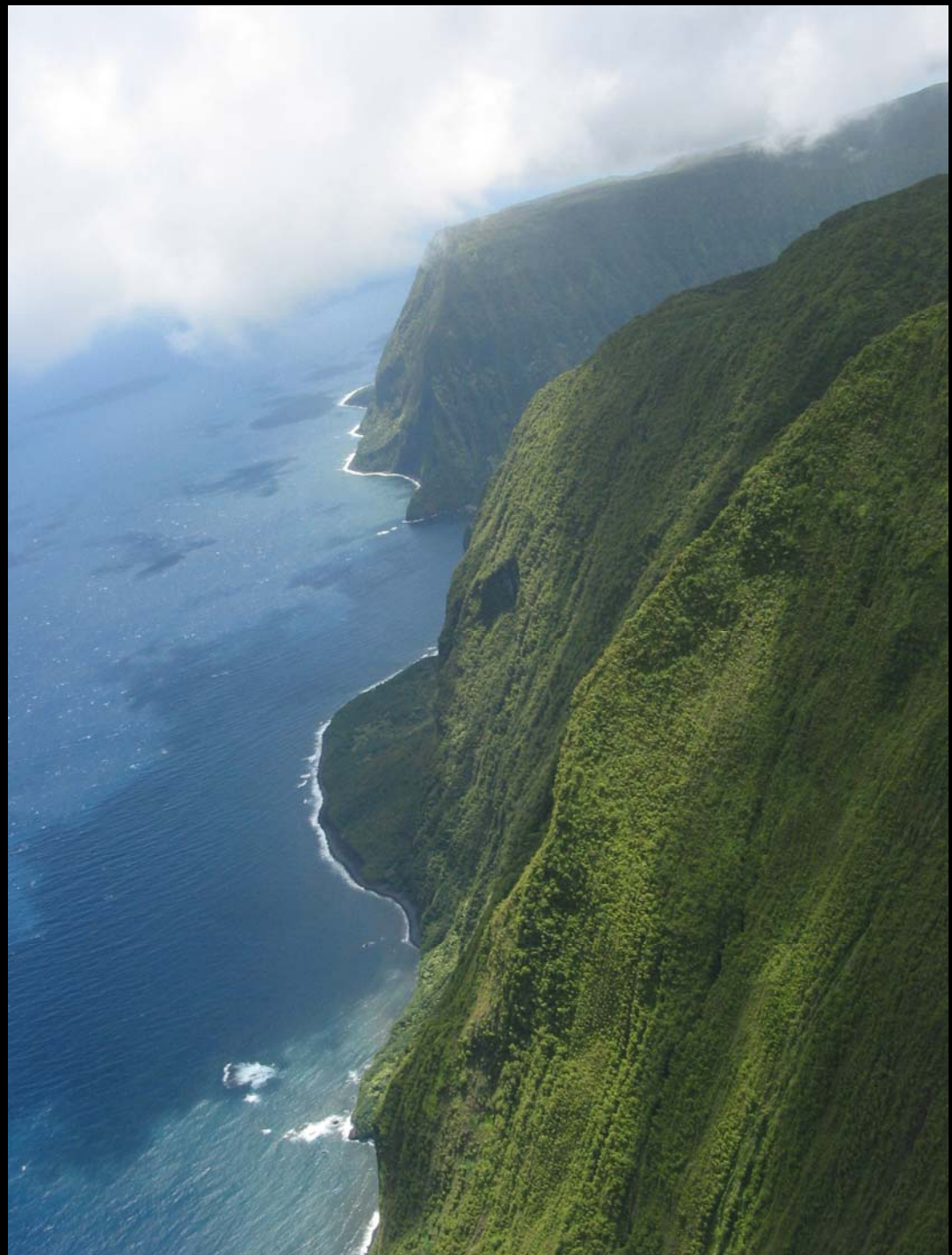
THE EXTERNAL LOAD OPERATION
DURING OPERATIONS UNDER PART
133.
WITH PARTICLE SEPARATOR
INSTALLED FLIGHT INTO FALLING
2004 08 10 17:52




2003 02 12 21:29